

MOTIVE POWER STUDY

Evaluation of Traction Power System

**Data Collection, Site Inspection, Staff Interviews,
and Inventory of Existing System**



Volume 1 of 3, Final Report

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**Volume 1: Data Collection, Site Inspection, Staff Interviews,
and Inventory of Existing System**

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1. INTRODUCTION

1.1 HISTORICAL PERSPECTIVE

1.1.1 Railroad Beginning

The rail lines now operated by the Metra Electric District were originally built by the Illinois Central Railroad (IC). The IC had begun operating southward from Hyde Park (53rd Street) on May 22, 1852. The first IC suburban service trains began running on July 21, 1856 from Randolph Street terminal to Hyde Park. The ridership grew at a spectacular rate, doubling between 1900 and 1920, by which time there were 294 daily train runs. To cope with the high number of passengers, the IC developed a highly efficient operation, introduced high level station platforms, purchased the Sullivan type cars with 10 doors per side, and began considering electrification.

1.1.2 Choice of Electrification System

Various systems of electrification were carefully studied before a choice was made. The choice was between direct current (DC) systems at moderate electrification voltage and alternating current (AC) systems at high electrification voltage. The DC systems would require more elaborate equipment on the wayside, but very simple equipment on the trains. The AC systems, on the other hand, required heavier and more expensive equipment on the trains, but minimal equipment along the wayside.

AC electrification system thus would be a good choice for a long distance electrification involving hundreds of miles of line and relatively few locomotive-hauled or multiple unit (MU) trains. DC system, on the other hand, seemed to be the best choice for the IC system electrification, which would involve only a relatively short line, but hundreds of electric MU cars. Since the traffic on IC's Mainline beyond the suburban territory was too light to offer any economic justification for long distance type of electrification, the choice thus was made to use a 1,500 V DC system. This voltage, about double that used by the elevated system and the streetcars, greatly reduced line losses and allowed substations to be spaced along the route at wider intervals.

1.1.3 Beginning of Electric Service

On July 21, 1926, the first electric suburban train ran from Randolph Street to 67th Street. Formal inauguration of electric operation through to Matteson took place on August 27, 1926. Soon electric trains covered all suburban service on the Mainline to Matteson, and the South Chicago and Blue

Island Branches. By 1929, 542 daily electric suburban trains were handling 121,000 daily passengers and the IC electrification was a resounding success.

1.1.4 Equipment Innovations

While the electrification was initially applied only to the suburban service, it was intended that it would eventually take over all freight and long-distance passenger operation within the city to eliminate smoke and noise of steam operation. The electrification system equipment was selected and designed with great care. For example, the IC requested the two major manufacturers of electrical equipment, General Electric and Westinghouse, to offer traction motors which were completely interchangeable. After extensive testing both motors were found to be satisfactory, and half of the order was placed with each supplier. The control equipment for all cars was supplied by General Electric.

Most of the substations had motor-generator sets to convert the AC power from the utility to the DC power required by the trains. A few of the substations were equipped with mercury arc rectifiers which were just beginning to be available. With no moving parts, the rectifiers required much less supervision and maintenance. A major innovation was that the substations would be owned and operated by Commonwealth Edison, rather than by the railroad. The utility was more accustomed to substation operation than the railroad and realized savings in equipment maintenance through economies of scale.

1.1.5 Recent Equipment Enhancements

In the 1970's the value of commuter service to the community was recognized and the South Suburban Mass Transit District, a predecessor of Metra, was created and provided assistance to the IC, by then merged into the Illinois Central Gulf (ICG) railroad.

New cars were purchased to replace the original electric cars. Following the lead of most of the other railroads operating suburban service in Chicago, the new cars were of the bi-level gallery type, providing the maximum number of seats per car. Because the IC operation, especially at the congested loop stations and the terminal, required passengers to be able to board and alight very quickly, the cars were designed with more doors than those of other railroads.

At the same time, automated fare collection was introduced on the ICG Suburban service as a major innovation. This was the first large-scale application of a system using magnetically-encoded tickets and fare gates which read the tickets electronically. Also, the original rotary converters and mercury-arc rectifiers in the traction power substations were replaced with solid-state rectifiers.

1.1.6 Metra Electric District System Today

In 1982 the operation of the Electric District has been taken over by Metra. Since the suburban passenger operation has been separated from the long-distance passenger and freight operations, the transition has been easier than in cases where commuter and freight operations had to be integrated on jointly-owned tracks.

Immediately upon beginning operation, Metra embarked on a modernization program of its facilities. This modernization included rehabilitation of the existing equipment as well as installation of new facilities.

The Metra Electric District rolling stock consists of 165 Highliner cars built between 1971 and 1978. All cars were overhauled between 1989-1996. The cars have been re-cambered, corroded steel has been replaced, and the car systems were reconditioned with some upgrades. However, the cars will soon reach the end of their useful life.

In the traction power substations, PCB-filled traction power transformers were replaced with dry-type or oil-filled transformers and the original AC and DC circuit breakers were replaced with modern switchgear. The DC feeder cables, the 4.16 kV lighting and power cables, and the 2.3 kV signal power supply cables were also replaced. Additional systems were introduced, such as the supervisory control and data acquisition system (SCADA), the DC circuit breaker fail protection, and the transfer trip protection.

The catenary system has undergone major rehabilitation. Contact wire wear is continuously monitored and significant sections of contact wire have been replaced. Although old, the present system is in a remarkably sound condition. The tensions in the conductors are being monitored and retensioning is performed as required. De-wirements are rare and a program of pole foundation repair is ongoing.

Much of the signal system today needs to be updated. The existing Mainline track circuits with US&S Model 15 relays are still very reliable but their maintenance and repair are costly, as the relays have not been available since the 1970's. The major interlockings, Randolph and Kensington, are in satisfactory condition being equipped with phase-selective coded track circuits. In the near future, the 67th Street Interlocking Tower is going to be replaced and split into three interlockings (65th, 67th and 69th) with the same type of track circuits. The Mainline south of Kensington is in the Centralized Traffic Control (CTC) territory and is controlled from the Central Control Facility (CCF).

The South Chicago Subdistrict signal system has had little or no updates since the 1950's. Along with maintenance of the many AC track circuits, maintenance of insulated joints is required. Because of the 36 (soon to be 38) at-grade crossings, much of the crossing protection has hold down circuits, station dwell time, speed measuring, and interlocking type relays for stick circuits.

The Blue Island Subdistrict is in marginally better condition than South Chicago Subdistrict. The single track systems includes one spring switch passing track.

The communication system for the Electric District is owned and operated by Metra. The system consists of telephone, radio, SCADA, station public address (PA), and station closed circuit television (CCTV) subsystems. There are two control centers serving the system. The CCF is the principal communications control center for the entire railroad operated by Metra. The second facility is the Passenger Assistance Link (PAL) Center. PAL's main function is to provide a manned communications link, both audio and visual, to Metra passenger stations on the Electric District. The communication equipment located at passenger stations, power substations, and other rail right-of-

way (ROW) locations are connected to the two control centers by fiberoptic, coaxial, and copper cables. These communications connections are supplemented by telephone voice and data circuits leased from Ameritech.

The Metra Electric District has six maintenance and storage facilities, Randolph Street/North Terminal, Weldon/18th Street Yard, Kensington Yard (KYD), Blue Island Yard, Matteson/Richton Park Yard, and University Park Yard/South Terminal. The facilities serve for routine inspection, light repair, major repair and overhaul, exterior car wash, interior car cleaning, wheel truing, and car storage.

The Light and Power (L&P) Transmission System supplies AC electrical power to passenger stations, Maintenance-of-Way (MOW) buildings, street/subway lighting, interlocking towers, bridges, signal system equipment, snow-melter systems, and other locations along Metra Electric District routes. The system consists of two distinct transmission subsystems, L&P Power four-wire, three-phase distribution system rated at 4.16 kV/60 Hertz, and Signal Power two-wire, ungrounded, single-phase distribution system rated at 2.3 kV/60 Hertz. Each of the subsystems receives power from the traction power substations via wire atop the overhead catenary system supports. Duplicate power lines are installed on the most critical portions of the Mainline.

1.2 PURPOSE OF THE STUDY

Since inception of the original electrification system, the electrical equipment operated safely and reliably. Today, some of the original equipment is still in service after more than 70 years of continuous operation. Due to the equipment age, some of the subsystems and components may be at the end of their useful life and need to be upgraded or replaced.

Furthermore, the existing cars that replaced the original electric cars are 20-30 years old. The cars have already undergone one rebuilt cycle, and now the car bodies are deteriorating. The cars still use the obsolete and inefficient cam-controlled propulsion system. With significant investments for the system modernization already committed, and a new large investment to replace the 165 cars potentially ahead, Metra wishes to evaluate the next step in the electric system development and assess how to continue serving the commuter passengers in the new century.

Taking into account the recent and projected passenger volume increases, the primary purpose of this study is to determine the answers to the following fundamental questions:

- What are the rolling stock replacements options? Should the existing rolling stock be replaced with the same type of equipment or should new technology, such as AC propulsion, be introduced?
- Would it be advantageous to use locomotive-hauled trains with trailer cars?
- Should the existing 1,500 V DC traction power supply and distribution systems be retained and augmented with additional power supply facilities to supply the projected level of service, or should the system be converted to a new electrification system operating either at 12.5 kV AC or 25 kV AC electrification voltage?

If the existing system is retained, it is necessary to answer the following:

- What modifications to the existing traction power system are required to supply year 2020 traction loads?
- What new equipment is required and what are the equipment ratings?
- What is the realistic, least service disrupting, and most cost-effective approach for implementing the system augmentation?
- What additional system components need to be renovated and upgraded?
- What is the cost of the system augmentation and upgrade?

In the event that either the 12.5 kV AC or the 25 kV AC system is more advantageous to Metra, the following questions need to be answered:

- What should the configuration of the new system be?
- What impact would the voltage increase and use of commercial frequency have on vehicle modifications, overhead catenary system clearances, signaling system compatibility, and change of other miscellaneous subsystems?
- What would be the environmental impact of the system conversion?
- What would be the operational impacts of voltage and frequency changes on Metra and the Northern Indiana Commuter District (NICTD)?
- What is the realistic, least time-consuming, and most cost-effective approach for implementing the system conversion?
- How would the system conversion be accomplished with minimum disturbance to train operation during construction?
- How would the new system construction be coordinated with vehicle conversion?
- What other system improvements are necessary due to obsolete equipment and change in voltage and frequency?
- What are the impacts of construction of new transmission lines for power supply to new substations?
- What are the major risks to successful project implementation?
- What is the cost of the system conversion?

Additionally, an evaluation into the possibility of dual-power locomotive (DPL) use is required. In the event that Metra extends its service in the future, *e. g.*, to the proposed South Suburban Airport (SSA) planned to be located near Peotone, Ill, by the State of Illinois Department of Transportation (IDOT), the DPL-hauled trains would be an option to extension of the electrification system.

1.3 SCOPE OF WORK

The Metra Electric District consists of the Mainline rail route between the downtown Chicago Randolph Street Station and the University Park Terminal. There are also two spur rail lines branching off of this Mainline, the South Chicago Branch and the Blue Island Branch. The study evaluates the systems used on the Metra Electric District commuter lines as shown in Table 1-1.

Table 1-1 - Metra Electric District Commuter Lines

Line Name	Extent of the Study	Approximate Route Length (miles)	Number of Passenger Stations	Maximum Operating Speed (mph)
System Mainline	Randolph Street to University Park	31.4	34	65
South Chicago Branch	Mainline to South Chicago 93 rd Street	4.7	8	30
Blue Island Branch	Mainline to Blue Island	4.4	7	30
Total System Under Study		40.5	49	

1.4 METHODOLOGY

The work on the project is divided into three tasks, and each task is, in turn, divided into subtasks as shown in Table 1-2.

Table 1-2 - Metra Electric District Study Tasks and Subtasks

Metra Study Tasks	Study Subtasks	
Task 1: Data Collection, Site Inspection, Interviews, and Inventory of Existing System	1.1	Data Collection and Review
	1.2	System Inspection and Evaluation
	1.3	Staff Interviews
	1.4	Inventory of Existing System
Task 2: Evaluation of Existing System	2.1	Existing Operation Criteria
	2.2	Rolling Stock
	2.3	Traction Power System
	2.4	Catenary System
	2.5	Signal System
	2.6	Communications System
	2.7	Storage and Maintenance Facilities
	2.8	Light and Power Transmission Line
	2.9	Real Estate Requirements
	2.10	Environmental Impact
	2.11	Cost Estimates
	2.12	Recommendation and Implementation
Task 3: Project Definition/Concept Planning	3.1	Design Criteria
	3.2	Rolling Stock
	3.3	Traction Power System
	3.4	Catenary System
	3.5	Signal System
	3.6	Communications System
	3.7	Storage and Maintenance Facilities
	3.8	Light and Power Transmission Line
	3.9	Real Estate Requirements
	3.10	Environmental Impact
	3.11	Cost Estimates
	3.12	Conclusions and Recommendations

The work performed in Task 1 is an indispensable effort which forms the cornerstone of the Motive Power Study. The purpose of the task is to prepare an overview and inventory of the Metra Electric District system elements, vehicles, and facilities.

Based on the Task 1, analysis of the existing Metra systems, vehicles, and facilities is performed in the Task 2 with regard to future system operation costs. A comprehensive power system study is performed for the current passenger density, and systems and facilities needing augmentation are identified. As some of the system components are more than 70 years old and might be close to the end of their useful life, consideration is given to future maintenance costs. The objective of this task is to evaluate and determine which parts of the Metra Electric District system can continue to be used, which parts need upgrading, and which parts need replacement.

In Task 3, alternative systems that could either supplement or replace the existing 1,500 V DC electrification system are evaluated taking into consideration passenger density projected for the year 2020. Any proposed electrification system needs to have sufficient capacity to supply adequate power to the trains and meet future system operating requirements. The objective of this task is to develop conceptual designs for at least three alternative systems, each capable of supporting Metra's operation projected to the year 2020. Impacts, benefits and costs of each system are required to be developed, and the most advantageous system for the Metra Electric District needs to be identified.

1.5 WORK PRESENTATION

Consistently with the three tasks outlined above, the Metra Motive Study report is presented in the following volumes:

- Volume 1 - Data Collection, Site Inspection, Interviews, and Inventory of Existing System
- Volume 2 - Evaluation of Existing System
- Volume 3 - Project Definition and Concept Planning

In order for each volume to be a stand-alone document, this introductory Section 1.0 is presented in each volume. For a comprehensive project overview, however, the reader should have an access to all three volumes.

2. SYSTEM INVESTIGATIONS

2.1 DATA COLLECTION AND REVIEW

The LTK Team requested from Metra staff key documentation associated with the existing electrified traction power supply system, the overhead catenary system, vehicles, and other related facilities. Listing of documents received from Metra is presented in Appendix B.

Based on review of the documents, site inspections of various facilities, and staff interviews were used as means to collect additional required data that were not otherwise available.

2.2 SYSTEM INSPECTION AND EVALUATION

The LTK Team performed site inspections of all system areas anticipated to be impacted by the potential changes in the electrification system. In order to obtain a status of the system, the following key facilities of the Metra system were visited:

- Traction power substations and tie stations - all substations and tie stations were visited.
- Catenary system - several representative sections of the system were visited and condition of the system foundations and poles were investigated. Inaccessible components, such as insulators, assemblies, and overhead wire attachments and hardware, were examined from ground level using binoculars.
- Existing rolling stock - a representative sample of the existing cars were inspected.
- Signal system - major signal system wayside facilities at interlockings and a representative sample of track circuits between interlockings were inspected.
- Communications system - major communications system facilities were visited.
- Storage and maintenance facilities - the KYD and Weldon facilities were inspected.
- Light and power transmission line - several representative sections of the line were visited together with the line feed points and load points. Inaccessible overhead fittings, such as cables and line hardware, were examined from ground level using binoculars.

In order to accomplish a consistent inspection results within each system and to ensure that the level of inspection is commensurate for this level of effort, specific inspection forms were developed for the various parts of the Metra system. During the inspections, the forms were filled out with pertinent information about the system and description of any apparent existing operating problem as appropriate.

2.3 STAFF INTERVIEWS

Meetings with all relevant Metra departments were arranged and field interviews with individuals maintaining and operating the various Metra systems, vehicles, and facilities were conducted. Particular attention was given to specific problems, if any, occurring due to poor performance of traction power supply system substations, tie stations, overhead catenary system, as well as rolling stock and its current collection and propulsion equipment.

Of particular interest was be the performance of the fixed termination catenary system under various climactic conditions. The pantograph-contact wire interface was observed at various locations, e.g., at high speed on tangent track, on curves, at section isolation locations, and at turnouts and crossovers.

2.4 INVENTORY OF EXISTING SYSTEM

Based on the foregoing work, an inventory of the existing system facilities was established. The collected information was entered into a database consisting of tables recording various levels of detail. The database can be modified by Metra to reflect study data, design criteria data, or as-built data. The database can be easily expanded to incorporate additional detail as further relevant information is identified.

The Metra Electric District alignment data are presented in tables in Appendix C. The tables show milepost of passenger stations, distance between the stations, number of tracks, and track miles. The information is compiled for the mainline, South Chicago branch, and Blue Island branch.

3. ROLLING STOCK

3.1 GENERAL

Three bi-level cars, nos. 1590, 1602 and 1621, were visually examined from the shop floor and from the pits underneath the cars. Additionally, the roof and upper level of one car was inspected from a mechanical lift platform. In general, the cars appeared in well-kept condition. Wheels showed slight flange wear, but no obvious flat spots or imperfections. The major detraction was bulging of internal corrosion along the side sill. Some spots were open; that is, the paint over the corrosion had flaked away. Some corrosion was also evident along the roof to side junction and some isolated spots on the sidewalls. Truck frames, under frames and end frames all seemed free of serious corrosion. No other problems, such as cracking or physical damage were observed.

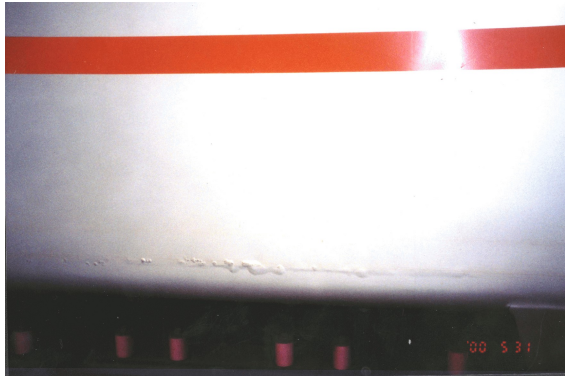
There was a preliminary discussion of the condition of and service experience with the various electrical equipment systems on the cars. In general, the equipment appears to be well maintained. The cars were in various degrees of rehabilitation, and some of the original equipment systems which proved troublesome have been replaced with more reliable equipment. Some of the systems, particularly the motor-alternator for auxiliary power and the propulsion cam controller, while serviceable, are obsolescent by current standards.

3.2 MECHANICAL INSPECTION

3.2.1 Car 1590

Paint on this car was bright with a good gloss, most likely because it was overhauled and painted within the 1994 to 1996 time frame. However, blistering from corrosion was noticeable all along the side sill, about four to six inches above the side frame bottom structure. Inspection of the corroded areas revealed that in some cases the corrosion is almost continuous and other locations relatively localized. Bulging corrosion was measured at the rear end of this car and was found to start just four inches from the bottom flange.

Examination of sidewall drawing shows that the structural side sill is behind the cover structure and that the area corroded is mostly the thin side wall sheet, which ends about four inches from the bottom flange of the side sill. The general foreman reported that when the cars were overhauled, the lower portions of the posts were also corroded. If these areas are now corroded, that would add to the repair costs.

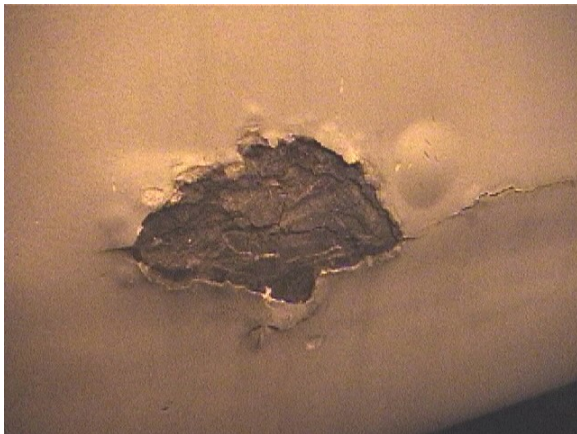


Example of Corroded Area

Visual examination of the underframe and truck structure found no obvious flaws. Examination of the side sill structural member found no severe corrosion or any significant loss of metal. Areas above the under floor sheeting were not visible for inspection.

3.2.2 Car 1602

This car apparently was not part of the 1994 to 1996 rebuild program. The paint was duller and some cracks in putty on the sidewalls were observed. One large corrosion area, about three inches in diameter, was found on the side sill and photographed. Otherwise, results were similar to car 1590. No faults were found during the visual inspection of the underframe and trucks.

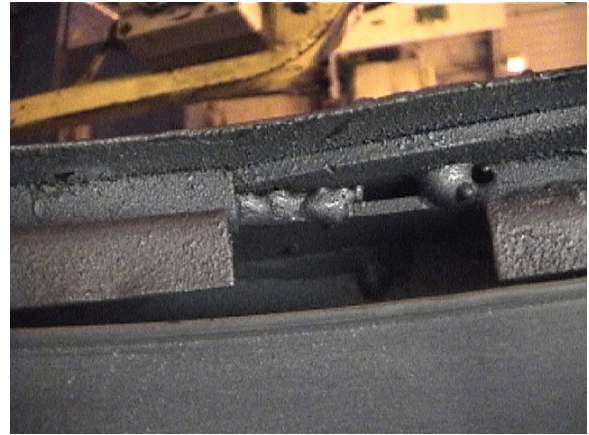
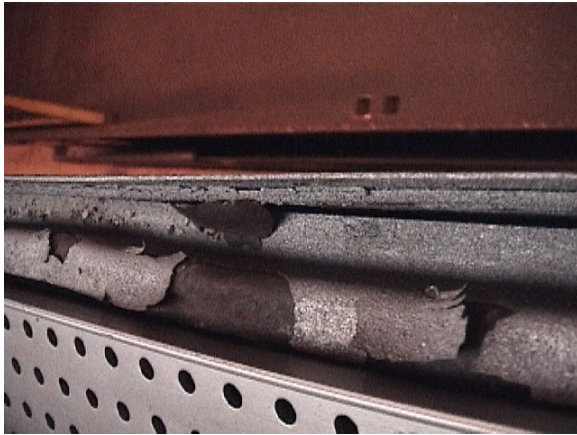


Example of Car Body Corrosion

3.2.3 Car 1621

Sidewall and underframe inspection findings were similar to car 1590. The roof and roof to sidewall areas were inspected from a lift platform and some corrosion was found at the roof to sidewall connection. Also, some rough areas were noted, probably locations of prior corrosion that were cleaned, but not smoothed with putty before final painting. The roof was painted with an aluminized roofing paint. There was no evidence of flaws or leaks.

One window molding had been removed exposing the sidewall sheet in this area. Inspection found paint peeling from the sheet metal, but no serious corrosion. Inspection of this area shows that corrosion has not removed any noticeable amount of metal from the surface.



Examples of Window Corrosion

One heater guard section was removed in an attempt to inspect the interior of the sidewall. However, there was a reflector behind the heater strip so that the sidewall construction could not be seen.

3.3 ELECTRICAL INSPECTION

3.3.1 Power Collection Equipment

The existing single-arm pantographs are giving satisfactory service. The carbon shoes last about 12 to 18 months in service, in spite of the fact that the contact wire is not staggered to distribute wear over the shoe. The railroad is exploring the possibility of installing bearings which would not require periodic lubrication, and therefore, minimize the need for roof access.

3.3.2 Auxiliary Power Supply System

At present, brush maintenance on the motor-alternator sets is the critical factor in determining the maintenance interval. Suppliers have not been able to supply brushes for these machines which will last for the FRA inspection interval of 92 days. Therefore, inspections are performed at 45 day intervals.

At the time the Highliner cars were built, motor-alternators were a better choice than inverters because power electronics was not well developed as yet. The situation has changed, and no-moving parts inverters are now the preferred technology..

The cars have lead-acid batteries. The battery box on car 1602 was inspected and appeared to be in good order.

3.3.3 Propulsion System

The present propulsion system, using switched resistor cam control and DC motors is serviceable, but obsolete. The cam controller of car 1622 was inspected and was in good condition. The original supplier contactors for main circuit transitions have been replaced with contactors of the type used in diesel-electric locomotives. These contactors are more reliable, and in addition provide some parts commonality with other Metra operations.

The traction motors are force-ventilated motors with filtered air. Filters are also applied to the exhaust openings in wintertime. To improve reliability, the traction motors are being operated below their nominal rating. Additionally, field shunting, which gives a higher maximum speed, has been disconnected to conserve energy. The motor couplings and gear units appear to be in satisfactory condition, but the couplings are beginning to show wear and an overhaul program is starting.

3.3.4 Friction Brakes

No problems were reported with the present air brake equipment. The compressors used are Sullair screw type and they are giving good results.

3.3.5 Couplers

Fully automatic hook-type mechanical couplers are used. The electric portions of all three cars appeared to be in good condition, with the contacts clean and showing no sign of undue wear.

3.3.6 Air Conditioning and Heating

Air conditioning units are self contained and can be removed and replaced as a complete unit through a roof hatch. The units have been overhauled recently and are receiving necessary cleaning and perform satisfactorily. The controls were replaced during a rehabilitation program. The units operate on 220 Volt, 60 cycle AC power from the motor-alternator.

3.4 COMMUNICATION AND ALERTER EQUIPMENT

Radio and Public Address systems have been updated. An alerter system, to meet current requirements, has been installed in addition to the original master controller deadman function. At present, no train control system is in use in this territory.

3.5 INVENTORY OF EXISTING VEHICLES

The inventory of the existing rolling stock is presented in Table D-1, Appendix D. The Table shows the major characteristics of the vehicles.

4. TRACTION POWER SYSTEM

4.1 GENERAL

The Metra traction power supply system consists of 10 traction power substations and 5 tie stations. All facilities are housed in the original brick buildings dating from 1920's when the system was originally constructed. The only exception is Jackson Street substation which dates from mid-1980's. The substation is housed in a modern brick building.

4.2 ELECTRICAL SYSTEM INSPECTION AND EVALUATION

During the system inspection, all traction power substations and tie stations were visited. Since much of the electrical equipment is relatively new, the substations were judged in good condition and capable to provide traction power to the Metra Electric District until the year 2020. The adequacy of the traction power substations to meet the requirements of the traffic densities expected in 2020 is evaluated in Volume 2 of this study. In the Volume 2, traction power system load-flow simulation are conducted and the load requirements of the individual substations are determined.

In recent years, major system upgrades and enhancements of the traction power supply system were completed. The PCB-filled traction power transformers were replaced during 1989 and 1995 with modern oil-filled and dry-type transformers. Majority of the substation contain oil-filled transformers. Dry-type transformer are used in the Cheltenham substation which houses two units, the 16th Street substation with three units, and the Brookdale substation having two units.

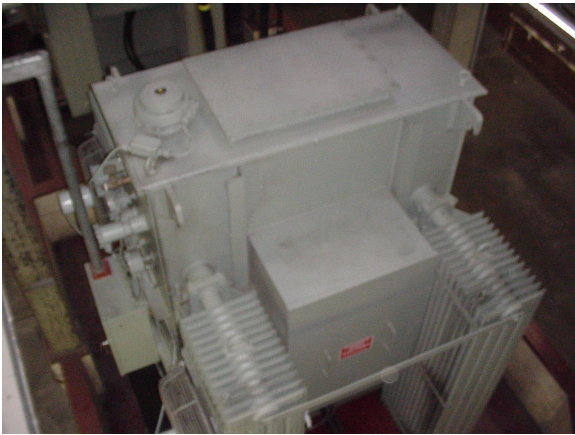
All substations, except Matteson and University Park, also supply the railroad Light and Power distribution circuits. All substation lighting was replaced in the 1990's, and filtered ventilation system was installed in the Jackson, Matteson, and University Park substations.

Obsolete 15 kV AC service circuit breakers were replaced with modern vacuum type switchgear in the late 1970s to late 1980's.

The original rotary converters in the traction power substations were replaced with solid-state rectifiers in 1970's. Typically, the rectifiers have a continuous rating of 1,333 A, with an overload rating of 2,000 A for 2 hours, 4,000 A for five intervals of 5 minutes, and 6,000 A for 45 seconds.

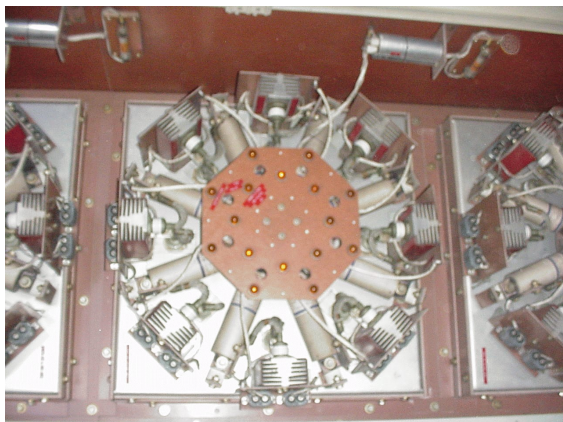
DC feeder circuit breakers were also replaced during the 1970's. Additionally, the DC feeder cables with lead armor were replaced during 1995-1999 period with new, rubber-insulated feeders. At the

same time the 4.16 kV lighting and power cables and 2.3 kV signal power supply cables were also replaced.



Substation Equipment is Shown in Good Condition

Additional systems enhancing the operation and protection of the traction power and distribution systems were introduced. The supervisory control and data acquisition system (SCADA) was installed during the 1960's and 1970's, and the DC circuit breaker fail protection and transfer trip protection were installed in the late 1990's.



Substation Equipment is Shown in Good Condition

4.3 STRUCTURAL INSPECTION

4.3.1 Jackson Boulevard Substation

The building is a single story structure, approximately 36' x 72' in size, with 6' high crawl space built in 1985. The exterior walls are of concrete masonry and load bearing. The roof consists of exposed steel joists and metal decking. The floor and crawl space structure is composed of concrete beams and slab.

There are two drains located at one side of building above the electrical equipment. No drain pans are provided. The overall condition of the building, including the roof, appears to be good.

4.3.2 16th Street Substation

The building is a single story structure of steel columns and masonry construction with full basement and mezzanine level. Based on field interviews, the building was previously owned and occupied by Commonwealth Edison. The building has uniquely detailed and constructed exterior walls, and may be on the historical landmark registry. The first floor is raised approximately 4' above grade level. The open floor space dimensions are approximately 60' x 75'. The first floor ceiling is approximately 25' high with transom windows. The roof and floor structure is composed of steel beams and concrete slab. The roofing consists of single layer of membrane and appears to be recently replaced.

The exterior front wall of building has two severe vertical cracks. These cracks appear to be on the veneer layer of brick caused by differential settlement of the building corners. Peeling paint and efflorescence on the brick walls at the drains indicate prior leaks.



Substation Structure is in Good Condition Except the Crack in the Outside Wall

4.3.3 51st Street Substation

The building is a four story structure measuring approximately 18' x 30'. The structure is composed of exterior brick masonry bearing walls and concrete floor slabs. Metra electrical equipment is located on the second floor accessible from the track level and a ladder from the street level. The building appears to be in good condition and no major deterioration was noted.

4.3.4 Brookdale Substation

This substation building is similar to the 16th Street substation in construction and size. There are minor differences in architectural detailing. The water markings around the interior drains indicate

severe water leakage in the past. The roofing is of a single ply membrane and appears to be new, approximately four to five years old.

4.3.5 95th Street Tie Station

The building is a two story brick and concrete structure approximately 24' x 35' in size. The building is located adjacent to the tracks making the second floor accessible from a parking lot at the back. A four car framed garage structure is attached to the main building. An adjacent brick masonry building to the west of the tie station is abandoned and in a state of deterioration.



Water Damage in Substation

The roof and floor structure is composed of concrete beams and slab. The first floor is accessed through a ship ladder from the second floor. The first floor has an entrance from the 95th Street. There are some cracks in the exterior masonry walls and general deterioration due to age. Old water piping and radiators are in close proximity of the electrical equipment. Overall, the building is in poor condition.

4.3.6 Front Avenue Substation

This substation construction is very similar to the 16th and Brookdale substations. The building is approximately 50' x 70' in size. The roofing is mechanically fastened single ply membrane and appears to be relatively new. The windows need repair and parts of the exterior walls need tuckpointing. Overall, the building structure is in good condition and requires regular maintenance and cleaning.

4.3.7 Riverdale Tie Station

The building is a single story structure with concrete block masonry bearing walls and a concrete roof slab. The building is approximately 12' x 40' large. Overall, the building is in good condition.

4.3.8 Homewood Tie Station

The building is a single story structure with concrete block and brick masonry bearing walls and concrete roof slab on concrete beams. The building is approximately 14' x 20' large. The exterior finish is plastered to match the adjacent station. Overall, the building is in good condition.

4.3.9 Harvey Substation

This building is similar in design and construction to the 16th and Brookdale substations except that the station also houses Com-Ed equipment. There is evidence of past water leaks at the interior drains located adjacent to the exterior walls. The brick walls at first floor and the basement have heavy efflorescence due to water penetration through the walls. There were no water leaks at the time of our visit. However, there is a lot of debris on the floor and walls from the deteriorated brick masonry.



Water Damage in Substation

The building requires cleaning and tuckpointing. It is understood that the roofing was replaced recently. The exterior concrete entrance stair has deteriorated and requires replacement or repair.

4.3.10 Vollmer Road Substation

The building is similar in design and construction to the 16th and Brookdale substations. The structure measures approximately 60' x 60' and is in good condition.

4.3.11 Matteson Substation

The building is a single story structure with crawl space. The building was built in 1970's and is approximately 27' x 65' in size. The structure is composed of exterior concrete masonry bearing walls, exposed steel joist, and metal decking with single ply membrane roofing.

There is fire damage to the roof in the interior of building. The damage was apparently caused by water falling on to the electrical equipment from a drain located above this area. Drain pans should be installed under all water piping and roof drains. The building is in very good condition.

4.3.12 University Park Substation

This structure is similar in design, size, construction and age to Matteson substation. As in Matteson substation, the roof drain lines are inside the building and require drip pans to protect the equipment. The building is in a very good condition.

4.3.13 Laflin Street Substation

The building is a single story structure with full basement level. The building measures approximately 45' x 45'. The building is in a very good condition.

4.3.14 Hegewisch Substation

The building is a single story structure with full basement approximately 60' x 70' large. The building design is similar to the Brookdale substation. The exterior walls have had water penetration marks and show efflorescence. Prior roof drain clogging and water leak is present at the drains.

4.4 INVENTORY OF EXISTING SYSTEM

The traction power substation and tie station inventory is presented in tabular form in Appendix E. The tables show the number and rating of the major equipment in the substations and tie stations.

5. CATENARY SYSTEM

5.1 CATENARY SYSTEM SUPPORTS

In general, the catenary system supports consist of riveted steel columns and trusses, either single or in pairs. The support structures include both portals and center poles with bracket arms. The portals are of fabricated steel, and the center poles are either 14 inch steel wide flange beams or 12 inch diameter steel pipes. Most of the structures are attached to their footings using anchor bolts. Most of the footings are concrete.

The foundations of most of the catenary structures visited were in fair to poor condition. Many of the foundations and base plates of catenary structures located in center of the two of tracks were buried under the ballast. In majority of the catenary structures, the base plates were rusted and in deteriorated condition. Some of the catenary structure foundations were recently replaced but the base plates were not. At these locations, the base plates continue to rust and eventually will require replacement.



Corrosion of Catenary System Supports

The catenary supports are being repaired on as-required basis in Metra's continuing program. The program was put in place in 1994 as a comprehensive plan for the replacement of the catenary foundations. A manual was produced by Metra's Engineering Department called "Procedure for Construction and Rehabilitation of Metra's catenary Foundations and Structures." It is a detailed menu of causes of the foundation problems and instructions for their replacement. This manual was used in training Metra crew in understanding the catenary system, forces involved and method of repair work. A number of foundations were replaced under this program. The program did not call for the replacement of the steel base plates or other repair work for the catenary structural steel.

The manual indicates that the primary steel components of the structure were in good condition at the time the manual was prepared. A general Structural Repair section of the manual outlines the repairs which may be required for handrails, crosswalks, and support arms. The repairs were to be

limited in scope, and now, the steel members show beginning signs of wear and rust.

In general, the catenary system consists of riveted steel columns and trusses, either single or in pairs. The overall catenary superstructure appears to be in good condition. The substructure, foundations, of most of the catenary structures visited was in poor to fair condition. Many of the foundations and base plates of catenary structures located in center of two sets of tracks were buried under the ballast. In majority of the catenary structures, the base plates were rusted and in deteriorated condition. Some of the catenary structures foundations were recently replaced but the base plates were not. At these locations, the base plate continues to rust and eventually will require replacement.

5.2 CATENARY SYSTEM TYPE

The catenary system is of the fixed termination type, with varying conductor tension as the ambient and conductor temperature changes. The system is free of mechanical section insulators, using air-breaks instead to perform the sectionalizing of the overhead 1,500 V DC power distribution system. This type of system sectionalizing using twin parallel contact wires to provide a sectioning overlap is an excellent feature of the installation and is typical of sectionalizing on all modern high-speed lines. On straight sections of track the contact wire is not staggered, but on curves staggers up to 12 inches are employed.

5.3 CATENARY SYSTEM CONDUCTORS

5.3.1 Catenary System Description

The catenary system comprises of a $1\frac{3}{16}$ inch diameter copperweld type E composite messenger, a 1/0 AWG and 4/0 AWG hard-drawn copper auxiliary messenger, and twin 4/0 bronze 80 contact wires. The typical span is 250 to 300 feet long. The two contact wires are alternately supported from the auxiliary wire by parallel groove contact wire clamps. Metra staff stated that these clamps were not being chaffed by the adjacent contact wire¹.

Technical data is sparse and a design criteria manual does not, per se, exist. Sufficient drawings and a few technical sheets are available for use by maintenance staff, but any proposed new design would benefit from having an approved design criteria manual already to hand. A drawing of each type of pantograph is required for reference. Overall, the catenary system appears to be in satisfactory condition.

5.3.2 Twin Contact Wire Arrangement

The twin contact wire catenary system inherited by Metra is a legacy of the past when high currents

¹ On the South Shore Line there is a serious wear problem with chaffing of contact wire clamps; in some cases the 'inner' lobe of the contact wire has been completely worn away.

were drawn by older designs of rolling stock. The original pantographs were less capable of handling the high currents than the pantographs currently available. The original pantographs, long since replaced, were supplied before the carbon-based rubbing strips, which are now an industry standard, had been developed.

Compared to catenary system using a single contact wire, the advantages of using twin contact wires include:

- Formation of air-breaks is easier. A single contact wire requires splitter clamps and operates with two contact wires at half-tension.
- Contact wire breakage is less catastrophic.

The disadvantages include:

- More equipment to maintain.
- More troublesome adjustment, especially on curves.
- Worse current collection.
- Chaffing between contact clamps of the two wires.
- Requirement to maintain equal tensions in each wire.
- More labor intensive re-tensioning of conductors.

5.3.3 Contact Wire Height

The normal contact wire height is 22', but this is lowered at some bridges to about 16' 6". The maximum operating height is 24' 8" and the minimum operating height is 16' 3". The cars have a height of 15' 10" and the pantograph lock-down height is 16' 0 $\frac{3}{4}$ ".

5.3.4 Contact Wire Registration

The catenary maintenance staff stated that they take care to ensure that all contact wire registrations, particularly along curves, keep the contact wire on the pantograph carbon. All crossover wires are registered to ensure that they ride straight onto the carbon and do not contact the pantograph horns first.

The condition of the catenary system is considered by Metra staff to have improved compared to five years ago, and there have been no wire tear-downs for at least two years. This is attributed to the increased maintenance and to the wire and component replacement program. Metra catenary maintenance staff performs routine daily inspections from both track level and from the car operator cabs, looking for defects, such as loose hangers, damaged insulators, and foreign materials hung up in the wires. Crews then make expeditious repairs and adjustments.

5.3.5 Allowable Contact Wire Wear

The contact wire wear allowed, before the wire is replaced, is 45%. This is more of an electrical criterion than a mechanical one. Should any worn contact wire be retensioned there is an important

condition. The tension that is applied onto the conductor needs to be equal to the original design tension multiplied by the remaining percentage of the cross-sectional area, *i.e.*, by 100% - % wear. In other words, the worn contact wire should be stressed to the same value in lb/sq. in. as a new wire, but not to the same tension in lb as a new wire.

Contact wire wear measurements are being taken on a routine basis, with a plan to check all the wire once a year. Sections of contact wire are being replaced on an as needed basis, but concern is being expressed that should multiple sections of wire approach wear-out level simultaneously, the present replacement rate would need to be accelerated. To anticipate this, Metra staff is proposing that some sections of contact wire should perhaps be replaced earlier than necessary to avoid possible delays.

5.4 PANTOGRAPHS

5.4.1 Pantograph Type

The GE pantographs used by Metra have four 40 mm wide carbon strips. Each strip is 35 inches long and consists of three sections of carbon that make up the full 35 inch carbon strip width. There are four carbon strips, two pairs spaced at about 11 inch centers. Each pair has a half-inch space between the carbons.

The dimension over the pantograph horns is 78 inches. Pantograph pressure is 23 lb. The maintenance staff take special care to keep each pantograph in adjustment.

5.4.2 Carbon Strip Wear Pattern

The pantograph carbon strip wear pattern is dish-shaped, deeper at the center as would be expected, and tapering upwards towards the ends. The depth of wear varies slightly between strips, and if the carbon strip is slightly tipped forward or backwards, the wear pattern is correspondingly tipped. The end 3 inches on both sides are little worn.

The leading edges of the carbon strips have minor nicks and chips, which is undesirable because chips often initiate grooving, leading to earlier replacement of carbon strips than normal. The cause of any excessive nicking and chipping should be determined, since it may indicate an underlying fault in the catenary system.

The allowable wear before carbons are replaced is when $\frac{1}{8}$ inch of carbon, or less, protrudes above the carbon holder. Additional care in refurbishing the pantographs to ensure the four carbons are coplanar, would be expected to increase the mileage traveled before replacement.

5.4.3 Carbon Life

The shop pantograph maintenance staff do not perceive the wear rate of the pantograph carbons as a problem as they only require to change, on average, about two pantograph heads per week. No

records are kept of the actual mileage achieved by pantograph carbons, but it is estimated that the whole fleet of 165 cars would have carbons replaced about every 18 months. None of the maintenance staff that were questioned had any source of information on individual car-mileage, or daily fleet-mileage on which to base pantograph carbon life. Cars averaging 75 miles a day for 18 months would cover about 40,000 miles, so a pantograph carbon life of 35,000 to 45,000 miles appears to be achieved, which is considered acceptable by Metra.

It is reported that LRVs in Sacramento achieve 100,000 miles, but other agencies only anticipate 50,000 miles, because they have mechanical section insulators along the mainline. The inference to be drawn is, that since Metra does not have mechanical section insulators in its mainline, the pantograph carbon life on Metra cars should be capable of improvement.

5.4.4 Carbon Life Extension

It is generally accepted that the life of pantograph carbons is shortened more by electrical wear, such as arcing and sparking, than by mechanical wear or abrasion. Figures of 75% electrical wear and 25% mechanical wear have been quoted. Electrical wear may be a systemwide trait or a purely localized matter.

System wide traits include the use of twin contact wires, too high a current density at the contact wire/carbon interface (unlikely on Metra lines), or too low a current density which will not create the smooth and shiny patina on the underside of the contact wire associated with excellent current collection, long pantograph carbon life, and low contact wire wear. Local electrical wear may be caused due to repetitious arcing at one particular point on the contact wire, such as at a section insulator.

Although Metra catenary system does not have mechanical section insulators along the system, it is presumed that there is a continuous pattern of light sparking, not to be confused with arcing, due to the use of twin contact wires. It is well known that sparks are drawn in the best adjusted catenary whenever a contact wire separates from the carbon strip, even when there is a continuous connection by the same carbon strip to the second contact wire. The use of a second contact wire may exacerbate sparking rather than improve current collection.

Arcing, particularly when it is associated with carbon impregnated pantographs can have reduced carbon life to under 5,000 miles where a high number of mainline section insulators are installed. Tests on pantograph carbons subjected to an arc have shown that the top surface of the carbon is softened and is, therefore, more susceptible to abrasion. The products of the abrasion are presumed to include carbon dioxide and carbon monoxide gases, but some of the impregnating copper is also released. Site inspections have determined that micron sized spheres of copper are produced which, amongst other places, stick to the contact wire ahead of where the arc was drawn. The now-spattered contact wire then acts like a rasp on any carbon strip that comes along, and causes accelerated wear.

Clearly any location of persistent arcing should be treated to prevent increased carbon wear, and as a precaution operators should be instructed to power-off through the offending location. As to whether continuous or repetitious sparking causes the same phenomenon is not known, but

inspectors of Metra's catenary should check the contact wire for the little copper bubbles that are the results of arcs.

5.4.5 Pantograph Head Alternatives

The GE pantograph appears over-heavy for the duty it has to perform. For instance, only two carbon strips should be needed for the typical currents being drawn from the catenary. When a larger area of carbon bears on the contact wires, the contact pressure is reduced, which can worsen current collection and increase electrical wear.

Most modern pantographs have only about 13 inches of metal horn beyond each end of the carbon, so that with a carbon rubbing strip only 35 inches long, the overall pantograph width need would be only be 61 inches. There is great benefit to reducing the overall weight of the pantograph head, since its reduced inertia improves current collection. Optional designs of pantographs would appear to be worthy of study.

5.4.6 Carbon Strip Alternatives

Metra staff stated that two pantographs have been supplied by Schunk for testing on the Metra system. These pantographs feature carbon strips manufactured in one piece, an uplift pressure of 17 lb, and an automatic retraction in the event of a pantograph head failure. It is presumed that the units are of the latest style. The Schunk carbon strips are wider and thinner than the three-piece strips on the GE pantographs. The new style carbons should have superior electrical (lower resistance) and mechanical (lower wear) characteristics than the existing carbons.

Suppliers are now making available new shapes of carbon strips, and there are increasing options in the types of metalized and non-metalized carbons available. These options need to be evaluated with the pantograph head alternatives.

5.5 RECONFIGURATION OF THE EXISTING FIXED CATENARY

5.5.1 Fixed Termination vs. Automatic Tensioning System

Conversion to auto-tensioned system would eliminate the need for extensive conductor re-tensioning each year to meet the disparate summer and winter temperature variations. The Metro-North Commuter Railroad developed a new auto-tensioned catenary style design and installed the equipment on existing structures spaced at approximately 300-foot intervals. There is no reason why Metra's existing catenary structures, which also have 300-foot spacing, could not be easily and economically adapted to carry auto-tensioned catenary.

At the present time the NICTD, having running rights over Metra tracks, is investigating the options for upgrading the fixed termination catenary system on the South Shore Line. Any future reconfiguration of the catenary system by Metra should include an exchange of information on

related topics.

5.5.2 Conductor Change

The existing catenary system, although built early in the last century, features equipment that is still serviceable. Any worn out items can be replaced. The demands on the catenary may be less electrically onerous now than they were when the system was first installed. Therefore, there may be opportunity to reduce the equivalent overhead system copper cross-section area, that is, to employ fewer or smaller conductors. Either a new catenary system could be designed from scratch, or the existing design could be simplified by possibly omitting the auxiliary messenger or replacing the twin 4/0 contact wires with a single 350 kcmil contact wire.

There are several alternative conductor combinations, but the most suitable configuration will be selected following a traction power system load-flow simulation study.

5.5.3 Contact Wire Height

On Metro-North lines the contact wire height was lowered from 22 feet to 17 feet for ease of maintenance. With the absence of grade crossings on Metra's tracks there is no reason why Metra's catenaries could not be similarly lowered if there is significant long term benefit such as easier access for maintenance.

5.5.4 Contact Wire Options

Contact wire materials, *i.e.*, Bronze 80, copper and silver copper, exist in several sizes, with 4/0 AWG, 300 kcmil, and 350 kcmil being the most common. The choice of twin contact wires over single, auto-tensioned over fixed termination system, and pre-sag over no-pre-sag are all options which require study. The practicality of any changeover, the short-term and long-term cost benefits, the labor pool and the efficacy and timing of the change compared to the ad hoc renewals now in hand, also factor into the analysis.

5.6 INVENTORY OF EXISTING SYSTEM

The inventory of the existing catenary is presented in Appendix F. The tables show the system configurations and ampacities.

6. SIGNAL SYSTEM

6.1 GENERAL

The running rails on Metra Electric District serve as paths for the negative traction return currents. The rails are also used for the signal system track circuits. The track circuits must function in the presence of the return currents which are hundreds of times greater than the track circuit currents flowing in the same rail.

At present, the following track circuits are used by Metra:

- AC Power Frequency Track Circuits
- Phase Selective Track Circuits
- Audio Frequency Train Activated Circuits
- Modulated Coded Track Circuits
- Audio Frequency Overlay Track Circuits
- Electrified Electro Code Track Circuits
- Phase Shift Overlay

6.2 AC POWER FREQUENCY TRACK CIRCUITS

The AC track circuits, shown in Figure G-1, Appendix G, are energized at power frequency of 60 Hz. The AC track circuits vary in length from 80 feet up to 5000 feet. Relay operation can be obtained by energizing the relay from two sources: the track and a local (line) AC supply. The relays require much less power from the track than from the line. The local AC line can furnish the bulk of energy required by the relay. Failure of the local supply does not impair safety since the relay can not operate unless both elements were energized.

The Union Switch and Signal Model 15 type AC vane relay is from 1920's. Different specification types (depending on track circuit length) were used: 1045, 1588 and Model SLV-13, specification 1288. The two-element vane relay consists of two separate windings, a radially slotted aluminum vane and three laminated cores: two used for the local circuit and one for the control (track) circuit. Since the Model 15 is a two-element relay, it has high efficiency, permitting relatively long track circuits. A laminated magnetic structure minimizes hysteresis and eddy current losses. The vane, which rotates through a limited arc in a vertical plane, operates the contacts through a crank linkage. The vane assembly includes a counterweight which provides gravity-actuated return to the contact-open position when either relay element is de-energized. These relays can no longer be purchased but can be repaired. Most of these relays are 70 years old.

6.3 PHASE SELECTIVE TRACK CIRCUITS

The Phase Selective Unit, shown in Figure G-2, Appendix G, compares the phase and amplitude of a coded track signal to a continuous local signal. The track signal and the local signal must be supplied from the same power source at all times, and must have the proper phase relationship and sufficient amplitude for the unit to drive a code following relay. The coding of the track signal provides a coded alternating polarity signal to a code following relay. When the relay is operating, the track is not occupied, and the system is operating correctly. Track occupancy or a system failure will cause the code following relay to stop coding.

When the track signal is not present, the local signal is coupled through the local transformer, rectified by the local rectifier bridge circuit, and output as a DC voltage. When the track signal is present, the relay bucks out the local signal which is coupled through the track transformer, rectified by the track rectifier, and output as DC voltage.

Depending on the track circuit length, *i.e.*, the amount of phase adjustment necessary to correct for track circuit phase shift, capacitor and the reactor tuned filter circuits assure operation at 100 Hz/200 Hz and provide immunity from electrical interference.

6.4 AFTAC TRACK CIRCUITS

Audio Frequency Train Activated Circuit (AFTAC), shown in Figure G-3, Appendix G, has been designed to provide a positive start for grade crossing warning systems by using a remote transmitter located at the desired start point with its associated receiver located at the grade crossing. The FM feature increases the safety factor with a high signal to noise ratio. Metra standard uses 12 sub-tones and 12 channels to choose from, AFTAC can be used in high density areas where AM or CW type systems would be limited in their application.

AFTAC is available in two power combinations:

- 1101: Low power (maximum transmitter output is 0.5 V AC) is designed for short distances up to 2,000 feet depending on frequency and ballast conditions.
- 1111: High power (maximum transmitter output is 3.18 V AC) is designed for distances up to 4,500 feet depending on frequency and ballast conditions.

AFTAC features high immunity to noise, eliminates need for insulated joints, and works with 12 V DC input. This type of track circuit is mainly used for crossing protection.

6.5 MODULATED CODED TRACK CIRCUITS

The Modulated Coded Track Circuit (MCTC) shown in Figure G-4, Appendix G, is connected directly to the rails. The reason the ICRR started using MCTC was to eliminate insulated joints and

impedance bonds by using a 10 foot loop and a one ohm hard wire shunt across the rails. The track circuit was center-fed with the transmitter connected directly to the rails. MCTC had 12 frequencies available and each frequency had three code rates and each code rate had four mod rates. In the mid-1980's the ICRR still had problems with this attempt using MCTC to eliminate insulated joints and impedance bonds. Metra now only has three track circuits of this type left near McCormick Place on Track 1, 2, and 3.

6.6 AUDIO FREQUENCY OVERLAY TRACK CIRCUITS (AFO)

The Audio Frequency Overlay (AFO) equipment, shown in Figure G-5, Appendix G, is designed to provide a long approach track circuit with the high degree of safety necessary in the control of highway crossings.

The AFO equipment consists of a transmitter unit and an associated receiver unit. Each unit is completely transistorized and is designed to operate from a nominal 10 V to 12 V battery.

Maximum track circuit length for low power AFO is 2,500 feet and high power AFO is 4,000 feet. Metra standard uses 12 different frequencies. This type of track circuit is mainly used for crossing protection.

6.7 ELECTRIFIED ELECTRO CODE TRACK CIRCUITS

The Electrified Electro Code (E² Code), shown in Figure G-6, Appendix G, is an AC interface for the Electro Code in electrified traction applications. The Electro Code is designed specifically for DC track circuits. The Electrified Electro Code Interface provides an AC (156 Hz) interface capability required for electric train circuits. AC signal generation and reception is performed without affecting the Electro Code outputs or inputs, the interface operation is transparent to it.

The E² Code is always used with an Electro Code. It applies proven track concepts used in DC-coded track circuits to electrified traction territory. E² Code is designed to be vital in application. Any hardware or software failure results in a safe display of wayside signal aspects. E² Code does require the need for a rectifier and battery for each unit.

The equipment features:

- High noise immunity.
- Compatibility with electrified traction power territory with AC or DC electrification.
- No costly wayside line wire circuits required for signal and traffic control.
- Communication of signal control information through the rails.
- Flexibility of microprocessor-based, vital coded track circuit capabilities suitable for any transit application.
- Generation of 100 Hz and 250 Hz cab signals to support automated train control.

6.8 PHASE SHIFT OVERLAY

The Phase Shift Overlay (PSO), shown in Figure G-7, Appendix G, consists of a separate transmitter and a receiver. The transmitter contains a single plug-in type printed circuit module. The receiver also contains a single PC module.

The PSO transmitter sends a coded, 8-bit address through the rails using an audio frequency signal as a carrier. The modulated signal is detected by the receiver where it is decoded and processed. The receiver responds only to signals of the proper frequency, modulation rate, address, and amplitude. The unique capability of the PSO to differentiate between the operating frequency and all other signals present on the track is due to the non-symmetric coded modulation and receiver decoding techniques which ensure that the system is immune to random or foreign AM, FM, and beat signals. The IC and Metra has experienced problems with the reliability of this type of track circuit.

The PSO II is available with two address codes and a wide variety of 16 carrier frequencies. PSO operates on 10 V DC to 12 V DC.

6.9 INVENTORY OF EXISTING SYSTEM

The inventory of the existing signal system is presented in Appendix G. The tables show a comprehensive overview of the track circuit types, lengths, and recommendation for future.

7. COMMUNICATIONS SYSTEM

7.1 GENERAL

The communication system for the Metra Electric District is provided, owned, and operated by Metra. It consists of telephone, radio, system control and data acquisition (SCADA), station public address, and station closed circuit television (CCTV) communication systems.

There are two Control Centers serving the system. The central dispatch center, called Central Control Facility (CCF), is the main communications control center for the entire Metra-operated railroad. The other is the Passenger Assistance Link (PAL) Center whose main function is to provide a manned communications link, both audio and visual, to Metra Passenger stations.

The communication equipment is located at passenger stations, traction power substations and other rail ROW locations are mainly connected to the two control centers by various fiberoptic, coaxial and copper cable systems in operation along various segments of the Rail ROW. These connections are supplemented by telephone voice and data circuits leased from Ameritech.

7.2 COMMUNICATIONS SYSTEM COMPONENTS

The Metra Electric Communication System consists of the following components:

- Microwave Radio System
- Telephone System
- Closed Circuit Television (CCTV)
- Automatic Revenue Collection System (ARCS)
- Public Address (PA) System
- Passenger Information Display System (PIDS)
- Substation Communication Equipment

7.2.1 Microwave Radio System

Metra's microwave radio transmission network is installed at various Metra properties. The Microwave Transmission Link is a 10 GHz Digital Carrier Loop operating between the Central Control Facility (CCF) and the KYD via Metra Antenna Towers. The sublink transmission paths are as follows:

- CCF to Main Metra Building at 547 West Jackson

- Main Metra Building to Western Avenue, Milwaukee District
- Western Avenue to 51st Street
- 51st Street to Blue Island
- Blue Island to KYD

A separate Microwave 2 GHz Analog Link is in operation between Blue Island and Joliet with sublink transmission paths:

- Blue Island to Mokena
- Mokena to Joliet.

The microwave radio system includes four radio tower locations for train operations control.

7.2.2 Telephone System

Seven Ericsson Phone System PBX's are installed at the following Metra locations:

- Main Offices at 547 West Jackson, Central Group PBX Switch
- CCF - Main Dispatch Center
- Randolph Street Station
- PAL Center - KYD
- Blue Island Station
- Chicago/91st Street South
- University Park

PBX Tie Line Circuits are transported in the fiber optic cable transmission system in operation along the mainline. The Metra telephone system utilizes a four digit extension, universal dialing plan, and includes elevator emergency telephones as well as cab and hall call buttons.

7.2.3 Closed Circuit Television System

Each passenger station is equipped with CCTV cameras and an intercom system located at the fare collection gates. The operating personnel at the PAL Center view passenger station interior areas on a video wall array of TV monitors as the station TV cameras are automatically scanned.

The operators have the ability to select a specific station when assisting passengers as they navigate through the fare collection gates at each Metra station. The passengers can also activate the system at their respective passenger stations by picking up a telephone located at the fare control gates, thereby contacting the PAL Center directly for assistance on matters related to rail fares, travel information, or security and emergency situations.

7.2.4 Automatic Revenue Collection System

The Automatic Revenue Collection System (ARCS) is used to collect revenue ticket data.

7.2.5 Public Address System

Public Address (PA) system, including loudspeakers and microphones, is designed to provide various types of audio messages to the traveling public. The system includes LED signs at two locations, but these are not synchronized with the audio messages from the PA system.

7.2.6 Passenger Information Display System

The Passenger Information Display System (PIDS) is controlled locally at each station to provide additional public announcements.

7.2.7 Substation Communication Equipment

7.2.7.1 Existing Substation Supervisory System

The communication equipment currently in use at Metra traction power substations consists of the following equipment:

- Telephone lines and leased data circuits from Ameritech. Typically, the Ameritech Cable Entrance/NET-POP is located on the inside rear walls of the substations. There are cable terminals with protectors for standard MB voice-grade telephone lines and analog data circuit terminals for the substation supervisory lines. Currently, none of these telephone lines or data circuits are carried by Metra along the fiber optic transmission or telephone cables.
- The existing substation supervisory and control equipment is of the older, coded stepper switch type. It allows for the monitoring and control of the substation equipment locally and more importantly remotely from the Randolph Street Control Room. The remote monitoring and control circuits are connected from each substation to the Randolph Street location via the leased lines from Ameritech and using cable termination co-located with the stepper switch equipment.
- Breaker Transfer Trip panels are connected between two adjacent substations. For example, from the 16th Street substation, transfer trip would initiate circuit breaker opening at Jackson substation to the north and 51st Street substation to the south. This equipment allows for ground fault monitoring and transfer of breaker tripping. The Breaker Transfer Trip panels are connected to each of the adjacent substations via telephone analog data circuits leased from Ameritech with cable termination equipment located at the cable NET-POP.
- Pyrotronics System 3 Fire Alarm panel monitored remotely at the Randolph Street Control Room via a leased Ameritech telephone line.
- Telephone connection to Metra via a leased telephone line from Ameritech.
- A CCTV system for local security purposes only. The system consists of a camera located on the outside wall viewing the substation street doorway entrance with a CCTV monitor located just inside that entrance. In some cases a similar CCTV camera/monitor system is installed at the back alley entrance. Door intrusion circuits are also installed.

7.2.7.2 New Supervisory Control and Data Acquisition System

Preparations are currently being made at the traction power substations for installing a new Supervisory Control and Data Acquisition System (SCADA) for monitoring and controlling the substation electrical power equipment and monitoring substation fire alarm system and doorway intrusion. The new SCADA System will be connected to the CCF via two telephone data circuits, SCADA Main and SCADA Backup. One data circuit will be the currently leased Ameritech data circuit and the second data circuit will be a channel in the existing fiber optic transmission system with microwave link back to CCF. The connections of the new SCADA system to the fiber optic cable system will be via newly installed Metra telephone cable between the substations and the mainline.

The new SCADA equipment cabinets are currently being installed at substations and tested back to the Main SCADA System equipment at CCF via the existing Ameritech leased data circuit. Cable junction boxes with 25 pair telephone cables from the Metra mainline right-of-way have been installed to the outside wall of the substations. These telephone cables will be terminated within the substations to serve the data circuits and the substation telephone line.

Metra is continuing to upgrade all SCADA systems and the SCADA communications will eventually move over from the currently leased Ameritech lines to the Metra owned fiber optic cable. When the addition of the Microwave back-up link is completed, the Metra communication system will be a completely self-healing network in the case of any fiber optic cable outages. Metra's communication system is continuing to improve and its reliance upon new technologies insures that it will remain on cutting edge in the future.

7.3 CONTROL CENTERS

There are two control centers serving the Metra Electric District: Central Control Facility (CCF) and Passenger Assistance Link (PAL) Center.

7.3.1 Central Communications Control Facility (CCF)

Metra's Central Control Facility, located at 1501 South Canal Street, Chicago, is the main communication control center for the entire Metra Rail System, including the Electric District. This facility contains three main elements of interest.

7.3.1.1 Communication Equipment Room

The main Communication Equipment Room contains the fiber optic cable and optical multiplexing equipment (OC-3), associated fiber optic node network management system, local telephone PBX equipment cabinet, microwave radio equipment, railroad system hi-band radio base station and site monitoring equipment, radio signal voting system, and Ameritech's fiber optic (OC-3) telephone service equipment.

7.3.1.2 SCADA Equipment Room

The new SCADA Equipment Room is located on the first floor and is currently being equipped with SCADA system equipment cabinets and monitors. Telephone jumper cables are installed as well as data circuits for the new SCADA Main and SCADA Backup equipment.

7.3.1.3 Rail Dispatch Control Center

The Rail Dispatch Control Center located on the second floor contains the Rail Control Dispatch Consoles for monitoring and controlling rail operations throughout the Metra system, and the Power Dispatch Room which monitors and controls the traction power substations along the Electric District and their respective circuit breaker equipment. All audio communications circuits are taped by existing audio tape recorders.

7.3.2 Passenger Assistance Link Center

The Passenger Assistance Link (PAL) Center control room is a communication control center which is centrally located on the Metra Electric District at the Kensington Yard and Maintenance Facility (KYD), 12701 South Indiana, Chicago IL 60628.

The main function of the PAL Center is to provide a manned communications link, both audio and visual, to passenger stations located along the mainline.

7.4 COMMUNICATIONS TRANSMISSION SYSTEM

Metra's communications transmission system is used to transmit voice, video, and other data the following subsystems:

- Telephone Dial and Audio Circuits
- Telephone PBX Tie-Lines
- Radio Control and Audio
- Station Public Address
- Station CCTV Video and Control Circuits
- Fiber Optic Network Management System
- Future SCADA Data Circuits

7.4.1 Fiber Optic Backbone Transmission System

The Metra backbone communications transmission system, which serves the Electric District mainline, consists of a 24 strand fiber optic cable network installed within the west side of the system right-of-way between Randolph Street station and University Park station. Only two of the fiber optic cable strands are currently used by Metra for transporting voice, and data to the Central Control Facility (CCF) and passenger station video to the PAL Center.

The fiber optic communications system consists of two OC-3 transmission loops:

- OC-3 Loop 1 - CCF to Randolph Street Station on Ameritech leased OC-3 circuit.
 - Randolph Station to KYD on ROW fiber optic cable.
 - KYD back to CCF on Microwave radio system.
- OC-3 Loop 2 - KYD to University Park.
 - Current Loop 2 Backup collapsible OC-3 ring within same 24 strand fiber optic cable.
 - Future Backup Loop 2 to be installed on the future microwave radio.
 - System Link between KYD and University Park.

7.4.2 Copper Cable Transmission System

The two rail branch spurs, the South Chicago Branch and the Blue Island Branch, do not have fiber optic cable installed. Instead they have a main copper cable transmission system installed along their right-of-ways for transmitting telephone voice, public address audio, and CCTV control circuits data. They also have a coaxial cable for transporting CCTV video from each of the passenger stations to the PAL Center at KYD.

The mainline between Randolph Station and University Park still has the old copper cables installed in place, mounted on aerial supports of the catenary system. The cable is abandoned at this time and will eventually be removed and scrapped.

7.5 EXISTING SYSTEM

Photographs of the existing communications system are shown in Appendix H.

8. STORAGE AND MAINTENANCE FACILITIES

8.1 GENERAL

There are six maintenance/storage facilities in the Metra Electric District. They are as noted below:

- Randolph Street, North Terminal
- Weldon/18th Street Yard
- Kensington Yard (KYD)
- Blue Island Yard
- Matteson/Richton Park Yard
- University Park Yard, South Terminal

Table I-1, Appendix I, lists these six facilities with an indication of the functions performed.

8.1.1 Storage and Maintenance

Three of the facilities are suitable for both, storage and maintenance functions, as noted in Table 8-1.

Table 8-1 - Storage and Maintenance at Metra Facilities

Name	Storage & Maintenance Function
Randolph Street, North Terminal	Car storage and interior car cleaning
Weldon/18th Street Yard	Routine inspection, light repair, exterior car wash, and interior car cleaning
Kensington Yard (KYD)	Major repair and complete overhaul
Blue Island Yard	Wheel truing and interior car cleaning
Matteson/Richton Park Yard	Car Storage and interior car cleaning
University Park Yard, South Terminal	Car Storage and interior car cleaning

8.1.2 Exterior Train Washing

Only one of these facilities, Weldon/18th Street Yard, is equipped to perform exterior train washing. The washing facility is located outdoors on the east side of the Weldon Shop. This facility can wash up to six-car trains.

A train is run past two sets of electrically-operated rotating brushes located on both sides of the track. One set of brushes provides a pre-soak and the other set provides scrubbing. The train must be run

in a reverse direction to be rinsed.

An operator in a glass-enclosed cubicle outside the shop building, can remotely control the operation, including the switch on every cycle from wash to rinse, and observe the result of washing. If needed, the back and forth movement of train can be repeated to ensure clean cars. For safety reasons, the section of overhead catenary system in the washing facility area is isolated and de-energized by means of hand-operated disconnect switch.

The Weldon Yard area is reported to suffer from high water table and the car washing no doubt contributes to this condition. The policy of Metra is not to allow a dirty train in commuter service. This facility, for obvious reasons, cannot be operated during freezing temperatures.

8.1.3 Interior Cleaning of Cars

At all six of these facilities, except KYD where in-service cars are stored overnight, the inside of the cars are thoroughly cleaned by crews during their layover period. A car that is not clean is not allowed in the service.

8.2 RANDOLPH STREET STORAGE YARD

8.2.1 Description

The Randolph Street facility is the north terminal of the Metra Electric District. There is no maintenance facility here. This facility serves the dual purpose of being a terminal station as well as storage facility. The passenger station is located underground.

8.2.2 Storage Yard Location

The storage tracks, which are located above ground, are situated between south of the Randolph Street station and north of the Van Buren Street station. The storage tracks include the two tracks on the east part of the yard.

8.2.3 Storage Yard Layout

The storage yard layout is shown in Figure I-1, Appendix I. As the two tracks which serve the dual purpose of mainline tracks and the storage tracks, there is no problem of exit from the storage or entry to the storage. The trains can enter the mainline either of the north side or south side.

8.2.4 Traction Power Feed

The Randolph Street station mainline tracks, as well as the yard tracks, are fed from the Jackson Boulevard traction power substation. This substation, incidently, also feeds the Chicago South Shore and South Bend (CSS & SB) Railroad overhead catenary system. The substation is located at the

track level on the east side of the tracks. All mainline traction power feed, except the cross-over section, are of heavy catenary construction.

The tracks which serve as the yard tracks are fed by Sections #3, #4, #5, and #6. The north side yard lead is fed from the main tracks through motor-operated switches (MODs).

8.2.5 Yard Condition

The storage yard condition is in relatively good condition. The problem of high water table, similar to Weldon Yard, is also reported to be present here.

8.2.6 Storage Yard Lighting

This yard suffers from inadequate lighting. The storage portion of the yard has to depend on the illumination from only a few flood lights.

8.2.7 Yard Crew Facility

There is no separate yard facility for yard crews. The yard crew has to depend on the main Trainman facility at the Randolph Street terminal or at the Van Buren Street station. The Trainman facility was recently renovated.

8.2.8 Yard Crew Parking Facility

There is no paved, parking facility for the yard crew. The unpaved spaces on both the east and west sides of the yard are utilized as parking facility.

8.3 WELDON/18th STREET STORAGE YARD

8.3.1 Description

The Weldon/18th Street storage yard is one of the facilities in the Metra Electric District, which has a maintenance shop in addition to the storage yard. This maintenance shop performs regular inspections, routine maintenance and minor repairs. In addition, the trains are made up here for evening rush hour operation. Trains are not stored here overnight, as they layover in the yards at the south end of the Electric District.

8.3.2 Storage Yard Location

The shop and the storage yards are located between the Mainline northbound and southbound tracks. The storage yard is divided into two sections, the west section and the east section. The east section of the yard contains the main storage facility.

8.3.3 Storage Yard Layout

The main yard entrance is on the north side where the northbound and southbound tracks connect to the shop and yard tracks. The shop tracks and the yard tracks are fed by catenary system of light construction. A schematic layout of the 18th Street Yard is shown in Figure I-2, Appendix I.

The east storage tracks and most of the west storage tracks are located beyond the south end of the shop. The east storage tracks are stub-ended tracks, having no connections to the Mainline from the south end. In the west storage yard only one track, track #3, is connected to the southbound Mainline track #2. Any track accident at the east side of the shop will effectively block all 52 cars in the east storage area.

8.3.4 Traction Power Feed

The west storage yard and the shop is fed by an independent traction power section #30. The east storage yard is fed by an independent traction power section # 31.

The west storage yard, consisting of tracks number #2, #3, and #4, also feeds the two north side shop tracks #3 and #4 and the Shop. The shop is fed at the south end.

Two north shop lead tracks, four south shop lead tracks at the south end of shop, the east storage tracks #5, #6, #7, #8, #9, #10, and #11, and the car wash tracks are all fed by traction power section #31 from the 16th Street substation.

8.3.5 Yard Condition

The spacing between the centerline of the storage tracks is 13' 0". With the car width of 10' 6", this track spacing leaves only 2' 6" between the cars for crew movement, which is very narrow. Also, there is not sufficient width to test wheel chair lifts. The storage yard area does not have any paved or wood plank walkway.

8.3.6 Storage Yard Lighting

There is inadequate storage yard lighting. The crew has to depend upon a few flood lights for night illumination. Since most operations here take place between the morning and evening rush hours, lighting is of less importance than it is at the yards at the southern end of the district.

8.3.7 Yard Crew Facility

The east side of the shop has a small office area. The toilet and the locker room of this office also serves as the crew facility.

8.3.8 Yard Crew Parking Facility

There is an unpaved area on the west side of the yard which serves as the crew parking facility.

8.3.9 Shop Condition

The shop has several significant problems that cannot be rectified by remodeling. These include:

- Severely undersized storage room
- Poor street access for delivery of parts and materials
- Short tracks unable to hold a complete 6-car train
- Shallow and poorly lit work pits under the cars
- Inadequate space for component repair shops

Metra currently has a consultant under contract to develop conceptual plans of a yard and shop at other locations. A schematic of the Weldon MU shop is shown in Figure I-7, Appendix I.

8.4 KYD SHOP

8.4.1 Description

The KYD shop is primarily dedicated to heavy repairs and wreck repairs. The only cars stored there are those queued to enter the shop for repair, or completed cars waiting to return to service. As shown in Figure I-3, Appendix I, there are really only two yard tracks besides those that feed the shop.

On the south side of the shop, four tracks are connected to the shop. Of these tracks, three east side tracks end up on the main shop floor and the fourth track on extreme west side ends up in the paint shop. The paint shop can paint only one car at a time.

The shop was opened in the early 1990's, and is in overall excellent condition. The shop plays a minimal role in the every day operations of the Electric District.

8.5 BLUE ISLAND STORAGE YARD

8.5.1 Description

Blue Island Storage Yard and Maintenance Facility is located at the end of Blue Island Branch. In addition to being a relatively small storage facility, it has an access to the only wheel truing facility available for the Electric District. The wheel truing machine is located nearby at the Rock Island District (RID) Blue Island Yard. Several years ago, the engineering department added a connection track to the RID yard.

When cars require wheel truing, arrangements are made with the RID to pickup the cars with a diesel switch engine and take them to the wheel truing shop. This operation is performed during the night shift. Normally, the cars can be trued and returned prior to the morning rush hour.

8.5.2 Location

The main storage yard is located to the west and north of the passenger station platform. The storage track on the east side of the platform is the same track which is used for northbound Mainline track.



Blue Island Yard Looking South

8.5.3 Layout

The storage track, on the east side of the passenger station platform also serves as the northbound Mainline track. The other two storage tracks are located on the west side of the passenger station platform. The number of trains and the train consist of each train are shown on the yard layout, Figure I-4, Appendix I.

8.5.4 Traction Power Feed

There is only one traction power section feeding the Mainline as well as the storage track. The traction power section # 297 from Laflin Street substation feeds the Mainline track as well as the storage tracks.

8.5.5 Yard Condition

Blue Island Storage Yard is relatively old. The condition of the yard calls for major renovation. Metra currently has plans to renovate the passenger station and the yard.

8.5.6 Yard Lighting

The yard lighting is inadequate. The crews can use the passenger station platform and for access to the cars. The platform lighting is the only lighting available.

8.5.7 Crew Facility

A small prefabricated structure, located at the north end of the platform, serves as the crew facility.

8.5.8 Crew Parking

There is no separate parking facility for the Metra crew. The Metra crews have to share a small paved area between tracks with the Rock Island Railroad crew for parking.

8.6 MATTESON/RICHTON PARK STORAGE YARD

8.6.1 Description

In addition to the 18th Street Yard, the Matteson/Richton Park Storage Yard between Matteson and the Richton Park passenger station is the main car storage facility for Metra Electric District. The storage facility consists of five yard tracks that can store 64 cars.

8.6.2 Location

The main part of the storage yard is located on the west side of yard track #1. There is no paved or wood plank walkway in the yard or between the storage tracks.



Richton Yard Looking South

8.6.3 Yard Layout

The yard track #1 also serves as the Mainline. All storage tracks are on the west side of the Mainline track. The yard track # 1, with a sectionalizing switch located within the yard area, is fed by an independent traction power section. The yard layout is shown in Figure I-5, Appendix I.

8.6.4 Traction Power Feed

The catenary system for the yard track #1 is of heavy catenary construction because this track also serves as the southbound mainline, while those for the yard tracks #2, #3, #4, and #5 are of light catenary construction.

The storage track #1 has an independent feed by traction power Section #241. The storage track #2 has an independent feed by traction power Section #247. The storage tracks #3, #4, and #5 are connected together and fed by an independent Traction Power Section #245.

All of these feeds originate from the Matteson traction power substation, which is located on the west side of the yard.

8.6.5 Yard Condition

The yard is in relatively good condition, however, there has been so much gravel added in the roadbed to aid walking, that the ties and ballast are covered and hard to inspect.

8.6.6 Yard Lighting

There is not adequate yard lighting. A few floodlights serve as the yard lighting at this location where most activities take place at night.

8.6.7 Crew Facility

There is a crew facility including foreman's office located on the west side of the yard. There are separate toilet facilities for male and female workers but there is only one locker room.

8.6.8 Crew Parking Facility

There is small, unpaved, unfenced parking facility for the crew. The land for this parking facility belongs to ComEd and is being leased by Metra. The access to the parking facility is via Route 127.

8.7 UNIVERSITY PARK STORAGE YARD

8.7.1 Description

The University Park Storage Facility (UP) is located at the University Park passenger station which is also the south terminal of the Metra Electric District. The storage yard is located on both the north and south ends of University Park passenger station. There are four storage tracks; three tracks on the south side of the station and one track on the north side.

The yard track #1 is extension of Mainline track. There is only one Mainline track between the University Park passenger station and Matteson passenger station. Also, the right-of-way is shared with CN/ICRR double track Mainline.

The trains leaving University Park station can be loaded from both sides of the centrally located platform. Hence there is no problem for pulling trains from the north storage track (which does not connect to Mainline on the north side) back to passenger station, loading the train, and go north. A total of 53 cars may be stored at this yard. Number of trains and consist sizes are shown on the yard layout Figure I-6, Appendix I.



University Park Facility Looking North and Looking from Passenger Station Platform

Between the two storage tracks, #1 and #2, there is an outdoor, uncovered, 250 gallon diesel fuel storage tank. The tank supplies fuel to an emergency generator used to power dewatering pumps. The pumps are located in the passenger access tunnel which connects the passenger station platform to the commuter parking lots adjacent to the east and west side of tracks. This tunnel occasionally gets flooded during heavy rains.

8.7.2 Traction Power Feed

The Mainline and the yard tracks #1 and #2 are fed by traction power section #312. The yard track #3 and the north storage track are fed by traction power section #310. The feeders originate from the University Park substation located on the east side of the passenger station. Both sections can be grounded by grounding switches.

The Mainline, storage track #1 and north storage track and storage track #2 are of heavy catenary construction, while storage track #3 is of light catenary construction.

8.7.3 Yard Condition

There is no paved walkway between the storage tracks. All the track switches are manually operated. All switch rails are electrically heated.



Damaged Switch Heater Cables

The loose cable condition pictured above was observed at nearly all locations. Such conditions should be evaluated to determine if it could become a safety, reliability, or code-compliance problem.

8.7.4 Yard Lighting

There is no proper lighting in the storage yard area.

8.7.5 Crew Facility

There is no separate yard crew facility at this location.

8.7.6 Crew Parking Facility

An unpaved area on the northwest side of the passenger station serves as the crew parking facility and the space for refuse containers. The area is fenced, but there is no gate or other security measures. This parking lot can be entered through Governor's Highway.

8.7.7 Mechanical Department Facility

On the south side of the passenger station, beyond the fuel oil storage tank for the emergency generator, there is an office facility for the mechanical department. This is the only facility for the yard crew to utilize for personal needs.

8.8 INVENTORY OF EXISTING FACILITIES

The inventory of the existing storage and maintenance facilities is presented in Appendix I. The Appendix also shows a physical track layout of each facility.

9. LIGHT AND POWER TRANSMISSION SYSTEM

9.1 GENERAL

The Light and Power (L&P) Transmission System supplies AC electrical power to passenger stations, Maintenance-of-Way (MOW) buildings, street/subway lighting, interlocking towers and bridges, signal system equipment, snow-melter systems, and other facilities along Metra Electric District routes. The L&P Transmission System consists of two distinct transmission subsystems, namely:

- Power distribution system rated at 4.16 kV, 3-phase, 60 Hertz, 4-wire, grounded. This system serves the passenger stations, MOW buildings, street/subway lighting, interlocking towers and bridges, snow-melter systems, and other locations.
- Power distribution rated at 2.3 kV, 1-phase ("C"), 60 Hertz, 2-wire, ungrounded. This system serves the signal system equipment.

Each of the subsystems generally receive their power from the traction power substations via physical wire installed atop the overhead catenary system supports. Duplicate power lines are installed on the most critical portions of the Mainline. Preferred line control is maintained by the substation power distribution monitor/control systems.

9.2 SYSTEM CONFIGURATION

9.2.1 Mainline System

The Mainline system configuration, as viewed from Metra's KYD facility near the Blue Island Branch merger includes insulated wires carried atop insulators. These insulators are mounted to four-pin or six-pin wooden or angle-iron cross arms, that are attached to catenary bridge structures or to top of catenary structure columns. The insulated wires are supported at heights of 33' to 36', with a sag of six feet per average 300 foot span.

Site observations have revealed that the cross arm angle-iron support attachments appear reusable. Other associated items, such as, insulated wires, pin insulators, wooden cross arms, and connection hardware, are showing need for replacement due to age and weather damage.

The Mainline system configuration, as viewed outside of Metra's Front Avenue substation indicated that some of the L&P power distribution system components have been renewed and replaced within

the last four years. Metra personnel indicated a renewal program is in place, and progress is being made on its implementation.



Typical Configuration of the L&P Distribution System

Recent L&P overhead replacement configurations now utilize a Metra approved wire/spacer cable system as manufactured by the Hendrix Company. Metra personnel noted that the system replacement has been on a site by site or spot replacement basis, and that has occurred mostly south of the Front Avenue substation. The system was physically observed being installed atop the eastside catenary portal going towards Metra's KYD yard.

The Mainline system configuration south of the Vollmer Road, bridge #28-86 and bridge #29-33 structures, which includes Matteson and University Park areas, relies wholly on a power connection to ComEd. This power distribution arrangement is completely isolated from the rest of the mainline L&P transmission system that ends at Vollmer Road. Extension and connection to the existing mainline system would provide system backup to the Matteson and University Park areas upon local ComEd line failure. Metra personnel have indicated that there is space available for an additional circuit breaker in the AC switchgear lineup at University Park substation. There is also space available in the substation yard to accommodate placement of a new L&P step-down transformer.

9.2.2 South Chicago Branch System

The existing South Chicago Branch system configuration, insulated wires atop insulators on cross arms, is presently being replaced as a part of Metra's ongoing L&P rehabilitation program. The replacement system being used is the Metra-approved wire/spacer cable system as manufactured by the Hendrix Company.

9.2.3 Blue Island Branch System

The present Blue Island Branch system configuration utilizes the Metra-approved wire/spacer cable system as manufactured by the Hendrix Company. Replacement of the original configuration, insulated wires atop insulators on cross arms was recently completed under Metra's ongoing L&P

rehabilitation program. Additional rehabilitation work on this branch will probably be done on as needed basis.

9.3 SYSTEM REHABILITATION PROGRAM

Metra is presently engaged in an ongoing rehabilitation program of the Electric Districts Mainline, and South Chicago and Blue Island Branches. These upgrades and enhancements are necessary to enable continuing operation of the system.

Based on visual inspections of representative sections of the L&P system and discussions with Metra technical staff personnel, it was concluded that the transmission system is operating satisfactorily at present. To date, various items of existing L&P Transmission System equipment have been replaced and/or enhanced, namely:

- Step-down transformers filled with PCB cooling fluids have been replaced with new dry-type or non-PCB filled transformers.
- New 5 kV distribution switchgear has replaced the old and obsolete circuit breakers.
- The system disconnect switches have been upgraded or replaced.
- Old lead-covered substation feeder cables have been replaced with new non-lead cables.
- Monitoring and control systems have been replaced. The new supervisory control and data acquisition system (SCADA), which was initially installed during the 1960's and 1970's, is being upgraded and enhanced as a part of the on-going Metra rehabilitation program.
- The overhead power distribution system including insulated wires, insulators, spacers and associated supports are being replaced by Metra personnel, as previously noted. To date, the Blue Island Branch has been completed, but work continues on the Mainline system and the South Chicago Branch.

9.4 INVENTORY OF EXISTING SYSTEM

The major characteristics of the existing Light and Power Transmission System are presented in Appendix J.

10. CONCLUSION

10.1 GENERAL

The Metra Electric District system components were reviewed and evaluated. The components included:

- Rolling Stock
- Traction Power System
- Catenary System
- Signal System
- Communications System
- Storage and Maintenance Facilities
- Light and Power Transmission Line

During the review and evaluation, numerous site visits were made and discussion were held with Metra personnel who maintain and operate these systems. Based on the site inspections and observations and taking into account the input from Metra personnel, the conclusions discussed in the following sections can be made.

10.2 ROLLING STOCK

Three bi-level cars were visually examined from the shop floor and from the pits underneath the cars. Additionally, the roof and upper level of one car was inspected from a mechanical lift platform. In general, the cars appeared in well maintained condition.

Wheels showed slight flange wear, but no obvious flat spots or imperfections. The major detractor was bulging of internal corrosion along the side sill. Some spots were open; that is, the paint over the corrosion had flaked away. Some corrosion was also evident along the roof to side junction and some isolated spots on the sidewalls. Truck frames, under frames and end frames all seemed free of serious corrosion. No other problems, such as cracking or physical damage were observed.

The cars were in various degrees of rehabilitation, and some of the original equipment systems which proved troublesome have been replaced with more reliable equipment. Some of the systems, particularly the motor-alternator for auxiliary power and the propulsion cam controller, while serviceable, are obsolescent by current standards.

10.3 TRACTION POWER SYSTEM

The traction power system upgrades included improvement of all components of the system. New 15 kV distribution switchgear has replaced the obsolete circuit breakers. The old PCB filled main step-down transformers have been replaced with new dry-type or oil-filled transformers. New power distribution switchgear has replaced older and obsolete circuit breakers. The old disconnect switches were replaced. Recently, a new DC circuit breaker transfer trip equipment has been installed. The aging power feeder distribution cables, leaving the substations and supplying power to the railway right-of-way overhead power distribution connection points, have been replaced with new non-lead covered cables.

10.4 CATENARY SYSTEM

The catenary system and the car pantographs are performing satisfactorily, and with no indications of any imminent or short term problems. Regular inspections and follow-up maintenance have avoided wire tear downs. However, some of the catenary foundations are in need of repair. Also, some of the catenary structural steel, such as the base plates, need replacement. Other structural steel members require cleaning and painting to prevent further deterioration. Metra's current catenary foundation replacement program can be expanded to include repair of the catenary structural steel as needed as well as painting and rust proofing the structures. A training manual, similar to the concrete foundation replacement manual, should be produced for the repair and painting of the structural steel.

10.5 SIGNAL SYSTEM

The signal system track circuits are being replaced with new microprocessor-based vital track circuits. The mainline signal system is in good condition. The South Chicago Sub District signal system has a total of 75 AC track circuits on four miles of double track railroad including 20 signals. In most cases, relays, gates, and signals are all aging and need to be replaced. The interlockings are in fair to good condition and are not in need of replacement. The Blue Island Branch is in marginally better condition than the South Chicago Line because some of the equipment has been recently updated.

10.6 COMMUNICATIONS SYSTEM

Metra is continuing to upgrade all SCADA systems and the SCADA communications will eventually move over from the currently leased Ameritech lines to the Metra-owned fiber optic cables. When the addition of the Microwave back-up link is completed, the Metra communication system will be a completely self-healing network in the case of any fiber cable outage. Metra's communication system is continuing to improve and its reliance upon new technologies provides Metra with the state-of-the-art communications system.

10.7 STORAGE AND MAINTENANCE FACILITIES

Metra has comprehensive storage and maintenance facilities to its disposal. The facilities enable Metra to store their fleet of cars and perform all maintenance functions including interior car cleaning, exterior car wash, routine inspection, light repair, major repair and complete overhaul, as well as wheel truing. Although several instances of inadequate lighting, access, and parking were noted, these are not serious problems.

10.8 LIGHT AND POWER TRANSMISSION LINE

The existing overhead power distribution system cables and associated supports are being replaced with a spacer cable type arrangement. To date, the Blue Island Branch has been completed and work continues on the Mainline and the South Chicago Branch. The existing power distribution monitoring and control systems have been replaced to ensure continuing operation of the system. The supervisory control and data acquisition systems (SCADA), initially installed during the 1960's and 1970's, are being upgraded as a part of the ongoing rehabilitation program.

Appendix A - GLOSSARY OF TERMS

A.1 GLOSSARY OF TERMS

Ampacity. Current-carrying capacity of a conductor, expressed in amperes.

Auxiliary Messenger Wire. Wire supported by the messenger which in turn supports the contact wire. The wire also acts as an auxiliary current conductor.

Catenary System. Overhead power distribution system providing traction power to electric locomotives and MU cars.

- Compound Catenary System - a system of messenger wire supporting an auxiliary messenger wire by the means of hangers which, in turn, support a contact wire by parallel groove clamps. The system is suitable for high speed application.
- Simple Catenary System - a system of messenger wire supporting a contact wire by the means of hangers. The system is suitable for medium speed to high-speed applications.

Catenary System Supporting Structures. Poles, towers, bridges, or other stationary structures used for supporting a catenary system including foundations, anchors, guys, braces, and similar reinforcing attachments.

Centralized Electrification Traffic Control (CETC) System. Computer-based system used for controlling operation of the traction power system and movements of trains.

Component. Item of complete hardware as commonly supplied by manufacturers.

Conceptual Design. A generalized plan describing design requirements and used as a guide to preliminary design.

Contact Wire. Conductor in contact with pantograph used by locomotives and MU cars to collect train power requirements. The conductor is suspended from messenger or auxiliary messenger by the means of hangers and contact wire clamps.

Contact Wire System. Overhead power distribution system providing traction power to electric locomotives and MU cars.

- Single Contact Wire System - a system of single contact wire without messenger or auxiliary messenger wire. The system is suitable for yard and shop applications.
- Twin Contact Wire System - a section of system where a contact wire is spliced into a messenger wire. The two contact wires are installed side by side and supported by insulated

supports attached to the underside of a structure, such a overhead bridge. The system is used in areas where the vertical clearance does not allow the use of compound or simple catenary systems. The system is suitable for medium speed to high-speed applications.

Directive Drawings. Drawings defining general arrangements or configurations of facilities for a particular project.

Disconnect Switch. A device used for disconnecting of de-energized items of equipment and sectioning of catenary system. Disconnect switches do not have a fault breaking capability, but may have some load breaking capability.

Distribution. Delivery of power from transmission system to an end-use customers at voltages greater than 110 V and less than 69 kV.

Electric Traction. A means for propulsion of railroad vehicles whereby power is provided by electrical energy transmitted from a remote source through a catenary system.

Final Design. A design stage during which final specifications, contract drawings, schedules, and cost estimates are prepared for specific construction project.

Frequency Converter. Frequency converter used for electrical traction purpose converts three-phase utility power of one frequency to single-phase power of different frequency.

- Rotary - Converter comprised of a three-phase motor and a single-phase generator.
- Static - Converter using semiconductor devices such as thyristors.

Grounded Equipment. Equipment connected to the conducting mass of the earth via ground rods, grounding grid or both to ensure an immediate discharge of electrical potential without danger.

Harmonics. Voltages and currents at frequencies other than the fundamental system frequency. Harmonics are caused by non-linear circuit components such as thyristors.

Harmonic Distortion. Due to the harmonic currents generated by thyristor-controlled equipment on board the rolling stock or in substations, the utility and traction voltage and current waveforms are not sinusoidal.

Impedance Bond. An iron-core coil of low resistance and relatively high reactance used to confine signaling current to its own track circuit and to provide a continuous path for the traction return current around insulated joints to substation.

Messenger Wire. Upper wire in a catenary system from which the contact wire is suspended by means of hangers.

Milepost. An identifier for a given location along a railroad line. Mileposts may or may not be located exactly one mile apart and may not be sequentially numbered.

Multiple-Fed System. Electrification system in which substations feed sections of catenary at multiple points. All conditions being equal, the multiple-fed system exhibits lower catenary voltage drop than the center-fed system. The system substations can have several traction power transformers or SFCs and operate with the substation low voltage bus-tie circuit breaker normally closed. Multiple-fed systems do not usually operate at commercial frequency because the entire system must be supplied at the same phase.

Power Demand Analysis and Load-Flow Study. A computer-aided study using specially written computer program to calculate the combined performance of the traction power supply and traction power distribution systems with operating trains. The study results include catenary system voltages, catenary system currents, substation power demand requirements and substation energy consumption.

Power Factor. Ratio of useful (real) power to total (apparent) power. Power factor is dependent on the locomotive propulsion system and substation converter design. Generally, the power factor is low at low train speeds and improves as the speed increases.

Power Transmission Factor. Ratio of transmitted power to power transmission capability.

Preliminary Design. A design stage at which specifications and drawings clearly show all major design elements and define requirements for final design. Design calculations are substantially complete, cost estimates are detailed to an extent compatible with the level of design, and a preliminary construction sequence schedule is prepared.

Span. Distance between catenary system structures.

- Length - Along track distance between structures.
- Width - Across track distance between the poles of a cross-span or headspan.

Station Dwell Time. That amount of time during which a train is stopped to open and close doors and receive and/or discharge passengers.

Substation. Traction power supply facility. Typical traction power substation includes power utility interface equipment, disconnect switches, circuit breakers, traction power transformers, switchgear, control equipment, signal power supply equipment, and auxiliary system. Special equipment, such as harmonic filtering and power factor control equipment, may be installed in substations as required. Substations serving electrification systems operating at other than commercial frequency also contain frequency converters.

Switching Station. Station containing circuit breakers or switchgear line up. Switching stations are located between substations and are used in AC electrification systems for switching section of distribution system during substation outage conditions and for paralleling of distribution system circuits.

Tie Station. Stations containing circuit breakers or switchgear line up. Tie stations are located between substations and are used in DC electrification systems for paralleling of distribution system circuits.

Traction Electrification System. Traction power supply and traction power distribution systems.

Traction Power Supply System. Traction power substations located at predetermined spacings along the route.

Traction Power Distribution System. Overhead catenary system or contact wire system which may be accompanied by overhead or underground along track feeders.

Trade-Off Analysis. A study of selecting a specific project alternative objectively considering all aspects related to all alternative methods of accomplishing the same action or an acceptable alternate action. Considerations include technical evaluations, environmental impact evaluations, and assessment of comparative costs.

Train Performance Simulator (TPS). A computer program representing operation of trains based upon tractive effort of the power units, resistance of the train to motion, and railroad alignment characteristics. TPS can calculate time, distance, speed, acceleration, power demand, energy consumption and loss relationships of a train for all station to station runs and for the whole route.

Transformer Cooling Class.

- OA - Self-Cooled
- FA - Forced-Air-Cooled
- FOA - Forced-Liquid-Cooled

Transmission. Delivery of power at a voltage of 69 kV or higher from generating units across interconnected high voltage facilities to points where the power enters distribution system.

A.2 LIST OF ABBREVIATIONS

A	Ampere
AAR	American Association of Railroads
A, B, C	High voltage system phase designations
AC	Alternating Current
ACSR	Aluminum Cable Steel Reinforced
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
AW0	Weight of empty, ready-to-run vehicle
AW1	Weight of vehicle with full seated load
AW2	Weight of vehicle with design load
AW3	Weight of vehicle with full load
AW4	Weight of vehicle with crush load
cmil	Circular mil
CN	Canadian National

DC	Direct Current
EIS	Environmental Impact Statement
EMI	Electromagnetic Interference or Electromagnetic Induction
EMM	Energy Management Model
ENS	Electric Network Simulator
EPR	Ethylene Propylene Rubber
ESI	Electrostatic Interference or Electrostatic Induction
FA	Forced-Air-Cooled
FOA	Forced-Liquid-Cooled
HV	High Voltage
Hz	Hertz
IGBT	Insulated Gate Bi-polar Transistor
ICRR	Illinois Central Railroad
kA	Kiloampere
kcmil	Kilo circular mil
kV	Kilovolt
kVA	Kilovolt-Ampere
kVAr	Kilovolt-Ampere Reactive
kW	Kilowatt
kWh	Kilowatt-Hour
LV	Low Voltage
MA	Motor-Alternator Set
M/G	Motor-Generator Set
MV	Medium Voltage
MVA	Megavolt-Ampere
MVAr	Megavolt Ampere Reactive
MW	Megawatt
MWh	Megawatt-Hour
N. C.	Normally Closed
N. O.	Normally Opened
non-RR	Non-railroad, not belonging to railroad
OA	Self-Cooled
O&M	Operation and Maintenance
p. u.	Per Unit
RMS	Root-Mean-Square

ROW	Right-of-Way
RR	Railroad
SCADA	Supervisory Control and Data Acquisition
TPS	Train Performance Simulator
V	Volt
XLPE	Cross-Linked Polyethylene

Appendix B - LIST OF INFORMATION RECEIVED FROM METRA

The following tables show listing of information received from Metra during the Task 1 investigations.

Table B-1 - List of Information Received from Metra - LTK

Title	Type	Identification
Metra South Suburban Airport Right Of Way	Maps from the Peotone study of 1998	
Metra South Suburban Airport Right Of Way		Appendix E
AC Power — 4.16/2.4kV, Power Supervisors, AC Operating Board	Drawing	BL 1450, Rev. 6
DC Feeder Diagram, Metra Electric District	Drawing	BL 1063, Rev. 2
Operations Profile	Electric District	April 15, 2000
Electrical Characteristics of Copperweld®-Copper and Copperweld® Conductors	Photocopy of Copperweld datasheet	
Bare Copper Stranded Conductor	Photocopy of Service Wire Co. datasheet	
Trolley Wire Copper	Photocopy of Service Wire Co. datasheet	
Commuter Rail System, Station Boarding/Alighting Count, Summary Results - Fall 1999		January 2000
Commuter Rail System, Station Boarding/Alighting Count, Train-by-Train Detail - Fall 1999		January 2000
System Employee Schedule Book		Effective January 1, 2000
Minimum Clearance Allowed by the Catenary System	Sketch	
Substation	Sketch	
ICRR, Chicago Terminal Improvement, Temperature-Tension Curve	Drawing	BL-1231
Ampacities of 300, 350, 500, & 700 MCM Bonding Cable	Datasheet	95 th Street March 13, 1982
Substation Locations (Metra)		
Directory of 1500V D.C. Substations and Tie Stations Serving the Illinois Central Gulf Railroad Suburban System		October 1983

Title	Type	Identification
D.C. Overhead Wire Clearance	Wire Height Measured on 3/26/86	
Electrified Suburban System Using Heavy System (.810 Mess.)	Table	6/19/84
Suburban Track Mileage	Table	7/15/76
Wire and Rail Resistance		
Technical Evaluation Form, Vendor: J. P. Simons	Catenary Wire	5/10/00
Blanket Purchase Order, Vendor: J. P. Simons	Catenary Wire	9/1/99
Metra Purchase Order System, Bid Pricing List: Catenary Hardware		Run Date: 10/7/99
Catenary Fitting, Clevis/Eye Extension Link Dropper	Drawing	CD-10053, File J2, Rev. D
ICRR, Chicago Terminal Improvement, Typical Arrangement Overhead Equipment, Single & Double Tracks	Drawing	A-2656
ICRR, Chicago Terminal Improvement, Typical Arrangement Overhead Equipment, Multiple Tracks	Drawing	A-2657
ICRR, Chicago Terminal Improvement, Catenary Fittings, Steady Arm Pull Off Fitting, Items No. 146 & 147	Drawing	D-2938
Metra Purchase Order System, Bid Pricing List: Catenary Utility Material		Run Date: 10/6/99
ICRR, Chicago Terminal Improvement, Links	Drawing	B-925
Post Type Insulator Plate	Drawing	BL-10435, Rev. 2
Illinois Central Gulf R.R., Double Link	Drawing	BL-903
Catenary Fittings	Drawing	D-917
Material List for Main Messenger Replacement, Track-1 Structure 10-21 to 7-91, FFA-3 RTA Project No. A8-0554 ICG AFE 8123	Drawing	CD-10515, Rev. A
Temperature Sag Curves, .81 Diam Copperweld Messenger Wire	Drawing	CD-10021, Rev. A
ICRR, Chicago Terminal Improvement, Typical Catenary Construction	Drawing	D-918
Mainline Air Section Insulator	Drawing	D-959, Rev. A
ICRR, Chicago Terminal Improvement, Signal & Catenary Structures, Typical 69-0 Structure	Drawing	D-3458
Final Report, Evaluate Service and Facility Alternatives for Metra Commuter Rail Service to the Proposed Peotone Airport		February 1998
Track Plans	Signal Drawing	
Power Distribution	Signal Drawing	
DC Feeder Diagram, Metra Electric District	Drawing	BL-1063, Rev. 2

Title	Type	Identification
Metra Electric, Chicago to University Park Timetable		Effective May 2, 1999
One Line Diagram, Jackson Blvd. Substation	Drawing	SS-0.70-4000, Rev. 1
One Line Diagram, ESS-Y13, 16 th St.	Drawing	Y13-400, 3/1/84
One Line Diagram, 51 st Street Tie Station	Drawing	SS-6.25-4003, Rev. 2
One Line Diagram, Brookdale Substation	Drawing	SS-8.69-4000, Rev. 2
One Line Diagram, 95 th Street Tie Station	Drawing	SS-11.9-4003, Rev. 1
One Line Diagram, Front Ave. Substation Relay and Instrument	Drawing	SS-14.8-4001, Rev. 2
One Line Diagram, Riverdale Tie Station	Drawing	SS-17.5-4003, Rev. 1
One Line Diagram, Harvey Substation	Drawing	460-400C, Rev. 1
One Line Diagram, Homewood Tie Station	Drawing	SS-23.9-4001, Rev. 2
One Line Diagram, Vollmer Road Substation	Drawing	SS-26.0-4000, Rev. 4/00
One Line Diagram, Matteson Substation	Drawing	SS-29.1-4000, Rev. 4
Relay and Instrument Single Line Diagram, University Park Substation	Drawing	SS-31.1-4001, Rev. 2
One Line Diagram, Cheltenham Substation	Drawing	Z14-400, Rev. 3
Electrical Power System One Line Diagram, Laflin Substation	Drawing	SS-2.62BI-4000, Rev. 2
A.C. Distribution Diagram	Drawing	BL-1069, Rev. B

Table B-2 - List of Information Received form Metra - PTG, Inc.

Title	Type	Identification
Single Line diagrams of the L&P Transmission System for all Substations	Drawings/Plots	Various
Drawing E-2 (Metra): South Electric Mainline - Overall Fiber Optic and Copper Cable Network	Single Sheet Drawing showing - Single Line Diagram FO & station breakouts and copper cable interfaces for substations.	E-2

Table B-3 - List of Information Received from Metra - STV, Inc.

Title	Type	Identification
Table of Contents	KYD Electrical Drawing List	Drawing #1
Electrical Site Plan 1 Sta. 807 + 65 to Sta. 818 + 00	KYD Yard and Shop Layout Sheet 1 of 4	E-1
Electrical Site Plan 2 Sta. 818 to 0 to Sta. 825 + 35	KYD Yard and Shop Layout Sheet 2 of 4	E-2

Title	Type	Identification
Electrical Site Plan 3 Sta. 838 + 35 to Sta. 838 + 70	KYD Yard and Shop Layout Sheet 3 of 4	E-3
Electrical Site Plan 4 Sta. 838 + 70 to Sta. 849 + 05	KYD Yard and Shop Layout Sheet 4 of 4	E-4
M-O-W and Mechanical Shops Symbol List	KYD Electrical Drawing Symbol List	E-5
M-O-W and Mechanical Shops 4.16kv, 1-line diagram	KYD AC Power Distribution for Shop & Yard	E-9
Plan-Catenary Structures Sta. 90 + 06 to Sta. 119 + 60 Structure 1-71 to Structure 2-27	Weldon Yard Plan and Profile of Catenary in Yard Area	D-1150
Symbol list, Abbreviations and Notes	Weldon Yard Drawings	E-1
Single Line Diagram	Weldon Yard , AC Power Distribution	E-2
Partial First Floor Plan/North Demo and Power	Weldon Yard Shop Layout	E-6
Partial First Floor Plan/North Demo and Power	Weldon Yard Shop Layout	E-7
Cross-section Lighting	Weldon Yard Cross-Section through Shop	E-10
Suburban Car Washer Electrical Plan	Layout of Car Wash	D-7995

Appendix C - METRA ELECTRIC DISTRICT SYSTEM ALIGNMENT

The following tables present alignment information of the lines comprising the Metra Electric District network.

Table C-1 - Metra Mainline Data

Milepost	Station	Distance Between Stations (miles)	Number of Tracks	Track Miles
0.00	Randolph Street	0.00	3	0.00
0.80	Van Buren Street	0.80	3	2.40
1.43	Roosevelt Road	0.63	3	1.89
2.22	18 Street	0.79	4	3.16
2.68	McCormick Place	0.46	4	1.84
3.20	27 Street	0.52	4	2.08
5.24	43 Street	2.04	4	8.16
6.54	53 Street	1.30	4	5.20
6.99	57 Street	0.45	4	1.80
7.43	59 Street	0.44	4	1.76
7.92	63 Street	0.49	4	1.96
8.33	67 Street	0.41	4	1.64
9.32	Grand Crossing	0.99	4	3.96
9.99	Chatham	0.67	4	2.68
10.38	Avalon Park	0.39	4	1.56
10.86	Woodruff	0.48	4	1.92
11.37	Chesterfield	0.51	4	2.04
12.04	Chicago State	0.67	4	2.68
13.06	103 Street	1.02	4	4.08
13.54	107 Street	0.48	4	1.92
13.95	Pullman	0.41	4	1.64
14.49	Kensington	0.54	4	2.16
17.33	Riverdale	2.84	2	5.68
18.18	Ivanhoe	0.85	2	1.70
18.98	147 Street	0.80	2	1.60
20.00	Harvey	1.02	2	2.04
22.27	Hazel Crest	2.27	2	4.54
22.82	Calumet	0.55	2	1.10
24.93	Flossmoore	2.11	2	4.22

Milepost	Station	Distance Between Stations (miles)	Number of Tracks	Track Miles
26.56	Olympia Fields	1.63	2	3.26
27.62	211 Street	1.06	2	2.12
28.24	Matteson	0.62	2	1.24
29.33	Richton	1.09	2	2.18
31.50	University Park	2.17	1	2.17
Total (miles)		31.50		88.38

Table C-2 - Metra South Chicago Branch Data

Milepost	Station	Distance Between Stations (miles)	Number of Tracks	Track Miles
8.33	67 Street	0.00	2	0.00
9.10	Stony Island Ave.	0.77	2	1.54
9.66	Bryn Mawr	0.56	2	1.12
10.28	South Shore	0.62	2	1.24
10.88	Windsor Park	0.60	2	1.20
11.49	Cheltenham	0.61	2	1.22
11.97	83 Street	0.48	2	0.96
12.51	87 Street	0.54	2	1.08
13.04	South Chicago	0.53	2	1.06
Total (miles)		4.71		9.42

Table C-3 - Metra Blue Island Branch Data

Milepost	Station	Distance Between Stations (miles)	Number of Tracks	Track Miles
14.49	Kensington	0.00	1	0.00
15.01	Blue Island Jct.	0.52	1	0.52
15.60	State Street	0.59	1	0.59
16.06	Stewart Ridge	0.46	1	0.46
16.68	West Pullman	0.62	1	0.62
17.04	Racine Avenue	0.36	1	0.36
17.87	Ashland Avenue	0.83	1	0.83
18.36	Burr Oak	0.49	1	0.49
18.91	Blue Island	0.55	1	0.55
Total (miles)		4.42		4.42

Appendix D - ROLLING STOCK

Table D-1 summarizes key data of the Metra rolling stock.

Table D-1 - Rolling Stock Data

Rolling Stock Data	
Type	Self-Propelled Gallery Car
Number of Vehicles, St Louis/Bombardier	130/35
Year of Manufacture, St Louis/Bombardier	1971-1972/1977-1978
Length	85 feet
Width	10 feet 6 inches
Minimum Pantograph Operating Height	16 feet 4 inches
Wheel Diameter (new/worn)	36 inches/33 inches
Weight, empty	140,000 lbs
Weight, full	164,180 lbs
Number of Seats (upper level/lower level)	64/92
Maximum Speed	75 mph
Maximum Acceleration Rate	1.36 mphps
Braking Rate	1.5 mphps
Nominal Line Voltage	1,500 V DC
Propulsion System Type	Cam controller and DC traction motors
Traction Motor Rating	150 HP continuous, 160 HP 1-hour
Number of Motors	2 per truck
Gear Ratio	4.07:1
Regeneration	None

Appendix E - TRACTION POWER SUPPLY SYSTEM

The following tables summarize locations and spacings of the Metra traction power system substations and tie stations.

E.1 SYSTEM SUBSTATIONS AND TIE STATIONS

Table E-1 - Metra Substation Spacings for the Mainline

Name	Facility	Milepost	Substation Spacing (miles)	Substation Spacing (miles)
	Beginning of Line	0.00	0.50	
Jackson Blvd.	Substation	0.50		1.32
16th Street	Substation	1.82	6.67	
51 st Street	Tie Station	6.04		
Brookdale	Substation	8.49		6.14
95 th Street	Tie Station	11.79		
Front Avenue	Substation	14.63	5.62	
Riverdale	Tie Station	17.68		
Harvey	Substation	20.25		5.59
Homewood	Tie Station	23.45		
Vollmer	Substation	25.84	2.74	
Matteson	Substation	28.58		2.59
University Park	Substation	31.17	0.03	
	End of Line	31.20		

Table E-2 - Metra Substation Spacings for the South Chicago Branch

Name	Facility	Milepost	Substation Spacing (miles)	Substation Spacing (miles)
	Beginning of Line	8.49	0	
Brookdale	Substation	8.49		2.82
Cheltenham	Substation	11.31	1.44	
	End of Line	12.75		

Table E-3 - Metra Substation Spacings for the Blue Island Branch

Name	Facility	Milepost	Substation Spacing (miles)	Substation Spacing (miles)
	Beginning of Line	14.63	0	
Front Avenue	Substation	14.63		2.96
Laflin	Substation	17.59	1.35	
	End of Line	18.94		

E.2 SUBSTATION DATA BASE

The following tables summarize key data of the Metra traction power substations and tie stations.

Table E-4 - Power Supply System Data for the Mainline

Power Supply Facility Type	Facilities		Data	
Substation	Name		Jackson Blvd.	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		3	2,152 kVA
	Number and Rating of Rectifiers		3	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	3	3,000 A
		Catenary Feeders	9	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-4 - Continued

Power Supply Facility Type	Facilities		Data	
Substation	Name		16 th Street	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	3	1,200 A
		Bus Ties	2	1,200 A
	Number and Rating of Traction Transformers		5	2,205 kVA
	Number and Rating of Rectifiers		5	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	5	2,000 A
		Catenary Feeders	11	2,000 A
		Transfer Buses	2	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Tie Station	Name		51 st Street	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders		
		Bus Ties		
	Number and Rating of Traction Transformers			
	Number and Rating of Rectifiers			
	Number of DC Circuit Breakers	DC Bus Incomers		
		Catenary Feeders	8	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Substation	Name		Brookdale	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	4	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		4	2,205 kVA
	Number and Rating of Rectifiers		4	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	4	2,000 A
		Catenary Feeders	10	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-4 - Continued

Power Supply Facility Type	Facilities		Data	
Tie Station	Name		95 th Street	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders		
		Bus Ties		
	Number and Rating of Traction Transformers			
	Number and Rating of Rectifiers			
	Number of DC Circuit Breakers	DC Bus Incomers		
		Catenary Feeders	8	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Substation	Name		Front Avenue	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	3	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		3	2,220 kVA
	Number and Rating of Rectifiers		3	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	3	2,000 A
		Catenary Feeders	9	2,000 A
		Transfer Buses	2	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Tie Station	Name		Riverdale	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders		
		Bus Ties		
	Number and Rating of Traction Transformers			
	Number and Rating of Rectifiers			
	Number of DC Circuit Breakers	DC Bus Incomers		
		Catenary Feeders	4	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-4 - Continued

Power Supply Facility Type	Facilities		Data	
Substation	Name		Harvey	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	NR
		Bus Ties	1	NR
	Number and Rating of Traction Transformers		2	NR
	Number and Rating of Rectifiers		2	NR
	Number of DC Circuit Breakers	DC Bus Incomers	1	NR
		Catenary Feeders	4	NR
		Transfer Buses	1	NR
		Spares	2	NR
Power Supply Facility Type	Facilities		Data	
Tie Station	Name		Homewood	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders		
		Bus Ties		
	Number and Rating of Traction Transformers			
	Number and Rating of Rectifiers			
	Number of DC Circuit Breakers	DC Bus Incomers		
		Catenary Feeders	4	2,000 A
		Transfer Buses	1	2,000 A
		Spares	1	2,000 A
Power Supply Facility Type	Facilities		Data	
Substation	Name		Vollmer	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		2	2202/2220 kVA
	Number and Rating of Rectifiers		2	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	2	2,000 A
		Catenary Feeders	4	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-4 - Continued

Power Supply Facility Type	Facilities		Data	
Substation	Name		Matteson	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		3	2,202 kVA
	Number and Rating of Rectifiers		3	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	3	3,000 A
		Catenary Feeders	6	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Substation	Name		University Park	
	Location		Mainline	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		2	NR
	Number and Rating of Rectifiers		2	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	2	3,000 A
		Catenary Feeders	2	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-5 - Power Supply System Data for the South Chicago Branch

Power Supply Facility Type	Facilities		Data	
Substation	Name		Brookdale	
	Location		South Chicago Branch	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		4	2,205 kVA
	Number and Rating of Rectifiers		4	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	4	2,000 A
		Catenary Feeders	10	2,000 A
		Transfer Buses	2	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Substation	Name		Cheltenham	
	Location		South Chicago Branch	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		2	2,150 kVA
	Number and Rating of Rectifiers		2	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	2	2,000 A
		Catenary Feeders	4	2,000 A
		Transfer Buses	1	2,000 A
		Spares		

Table E-6 - Power Supply System Data for the Blue Island Branch

Power Supply Facility Type	Facilities		Data	
Substation	Name		Front Avenue	
	Location		Blue Island Branch	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	2	1,200 A
		Bus Ties	1	1,200 A
	Number and Rating of Traction Transformers		3	2,220 kVA
	Number and Rating of Rectifiers		3	2,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	2	2,000 A
		Catenary Feeders	9	2,000 A
		Transfer Buses	2	2,000 A
		Spares		

Power Supply Facility Type	Facilities		Data	
Substation	Name		Laflin	
	Location		Blue Island Branch	
	Number and Rating of AC Circuit Breakers	Incoming Feeders	1	1,200 A
		Bus Ties	0	1,200 A
	Number and Rating of Traction Transformers		2	1,106 kVA
	Number and Rating of Rectifiers		2	1,000 kW
	Number of DC Circuit Breakers	DC Bus Incomers	2	1,500 A
		Catenary Feeders	2	2,000 A
		Transfer Buses	0	2,000 A
		Spares		

Appendix F - CATENARY SYSTEM

The existing catenary system comprises the conductor configurations as shown in tables F-1 and F-2.

Table F-1 - Power Distribution System Detail Data - Mainline North of 63rd Street, South Chicago Branch, and Blue Island Branch

Conductor	Number of Conductors	Size	Material	Approximate Ampacity (A)
Messenger Wire	1	$\frac{13}{16}$ " 7-CW Wires, 12 Cu Wires	Copperweld-Copper	610
Auxiliary Messenger Wire	1	4/0 AWG	Hard Drawn Copper	480
Contact Wire	2	4/0 AWG	Hard Drawn Copper	780
Total Ampacity				1,870

Table F-2 - Power Distribution System Detail Data - Mainline South of 63rd Street

Conductor	Number of Conductors	Size	Material	Approximate Ampacity (A)
Messenger Wire	1	$\frac{13}{16}$ " 7-CW Wires, 12 Cu Wires	Copperweld-Copper	610
Auxiliary Messenger Wire	1	1/0 AWG	Hard Drawn Copper	310
Contact Wire	2	4/0 AWG	Hard Drawn Copper	780
Total Ampacity				1,700

Ampacities for conductors operating at temperature of 75°C in sun and wind conditions, AREA Manual for Railway Engineering, Chapter 33, Electrical Energy Utilization, Part 4, published in 1991. Contact wire is assumed to be worn to 70% of its original cross-section area.

Appendix G - SIGNAL SYSTEM

G.1 MAJOR INTERLOCKING DATA

G.1.1 Randolph Street

The following interlockings are used in Randolph Street:

- Number of track circuits: 37
- Type of track circuits: AC Phase Selective, US&S equipment.

The interlocking was installed in 1988.

G.1.2 51st Street

The following interlockings are used at 51st Street:

- Number of track circuits: 4
- Type of track circuits: AC with GRS plug type. These relays still available.

The interlocking will be retired as part of current Metra upgrade project. The new interlocking will be called C.P. 45th Street at 282+85 signal bridge 536 to 296+60 signal bridge 562.

G.1.3 65th, 67th and 69th Streets

The 65th, 67th and 69th Street interlockings are planned to be installed in the near future:

- Number of track circuits: 22 for all three locations
- Type of track circuits: AC Phase Selective, US&S equipment.

G.1.4 Kensington

The following interlockings are used at Kensington:

- Number of track circuits; 15 on Metra, 11 on CN/ICRR
- Type of track circuits: AC Phase Selective, GRS equipment.

The interlocking was installed by the ICRR in 1984

G.2 TRACK CIRCUIT DETAILS

The following spreadsheets present all existing track circuits on the Metra Electric District. The data is organized as follows:

- **Table Horizontal Designation.** A track circuit in block signal territory is assigned with a nomenclature that usually is associated with the block signal that governs over it. The block signal number is derived from the catenary bridge location or milepost number. Between Randolph Street and Kensington, which is signaled in single direction only, the signal number derives from the bridge number. For example, 1-764 for Track #1, 2-764 for Track #2 and signals northward for Track #3 is 3-764 and Track #4 is 4-764.
- **South of Kensington, on the Blue Island and South Chicago subdistricts, the southbound signals are usually designated by odd numbers and northbound signals by even numbers. Interlocking track numbers are usually associated with those assigned to switches.**
- **Type of Track Circuit.** The notes indicates a type of track circuit and a schematic Figure number.
- **Length of Track Circuit** is the footage from the transformer end to the relay end (as in this case) insulated joint to insulated joint.
- **Future Planning.** Indicates whether the signal department is evaluating or planning installation.
- **Recommend Replacement.** Indicates whether there is a suitable or better replacement for the signal track circuit.

G.3 SUMMARY OF TRACK CIRCUITS

The type of track circuits by type are shown in Table G-1 for the Metra Electric District Mainline, South Chicago Branch, and Blue Island Branch.

Table G-1 - Metra Track Circuit Summary

Type	Mainline	South Chicago Branch	Blue Island Branch	Total
AC Track Circuits	138	75	57	270
Electrified Electro Code E ² C	5	0	0	5
AFO	3	32	0	35
AFTAC	0	7	11	18
PSO	2	0	2	4
MCTC	3	0	0	3
Total Number of Track Circuits				335

The Tables G-2 through G-11 show comprehensive review of the existing track circuits and recommendations for future.

Appendix H - COMMUNICATIONS SYSTEM

The photographs in this Appendix show examples of the existing communications system facilities.



New SCADA and RTUs



PAL Center Control Room



Microwave Tower at CCF



CCF Control Room



CCF Control Room

Appendix I - STORAGE AND MAINTENANCE FACILITIES

The following tables show listing of Metra storage and maintenance facilities.

Table I-1 - Metra Storage and Maintenance Facilities

Name	Function of Facilities				
	Car Storage	Routine Inspection and Light Repair	Major Repair	Car Wash	Wheel Turning
Randolph Street Terminal	Yes				
Weldon/18th Street	Yes	Yes		Yes	
Kensington (KYD)			Yes		
Blue Island Terminal	Yes				Yes
Matteson/Richton Park	Yes				
University Park Terminal	Yes				

Table I-2 - Metra Storage Yard General Data

Name	Number of Storage Tracks	Number of Cars Stored	Paved Walkway	Yard Lighting	Employee Parking	Crew Facility	Layout Figure No.
Randolph Street Terminal	1	20					I-1
Weldon/18th Street	10	80	No		Yes	No	I-2
Kensington (KYD)							I-3
Blue Island Terminal	3	14	No	No	Yes	No	I-4
Matteson/Richton Park	5	64	No	No	Yes	Yes	I-5
University Park Terminal	4	53	No	No	Yes	No	I-6

Layout of the Weldon/18th Street shop is shown in Figure I-7.

Table I-3 - Metra Storage Yard Electrical Data

Name	Number of Traction Power Sections	Independent Feeders	Substation Feeders from Mainline	Substation	Remarks
Randolph Street Terminal				Jackson Substation	
Weldon/18th Street	30	Yes		16th Street Substation	Section 31 also feeds the shop
	31	Yes			
Kensington (KYD)	293	Yes		Front Avenue Substation	
Blue Island Terminal	297		Yes	Laflin Street Substation	
Matteson/Richton Park	241		Yes	Matteson Substation	
	247	Yes			
	245	Yes			
University Park Terminal	312		Yes	University Park Substation	
	310	Yes			

Appendix J - LIGHT AND POWER TRANSMISSION LINE

The Light and Power Transmission Lines distributes power to the passenger stations and to signal system. Tables J-1 and J-2 present the basic data for both transmission lines.

Table J-1 - Station Power Distribution System Data

Characteristic		Mainline	South Chicago Branch	Blue Island Branch
Power Distribution System Type		Overhead Line	Overhead Line	Overhead Line
Voltage		4.16 kV	4.16 kV	4.16 kV
Number of Phases		3	3	3
Frequency		60 Hz	60 Hz	60 Hz
Conductor Size	Existing	#2 AWG, #1 AWG	#1 AWG	1/0 AWG
	New	#2, 1/0, 4/0 AWG, 397 kcmil	1/0 AWG	
Conductor Material	Existing	Copper	Copper	Aluminum
	New	Aluminum	Aluminum	
Line Configuration	Existing	4-wire, insulators atop crossarms	4-wire, insulators atop crossarms	3-wire Hendrix system
	New	4-wire Hendrix system	4-wire Hendrix system	
Load Served		Passenger Stations, MOW Buildings, Street/subway Lighting, Interlocking Towers, Bridges, Snow-Melter Systems		

Table J-2 - Signal Power Distribution System Data

Characteristic		Mainline	South Chicago Branch	Blue Island Branch
Power Distribution System Type		Overhead Line	Overhead Line	Overhead Line
Voltage		2.3 kV	2.3 kV	2.3 kV
Number of Phases		1	1	1
Frequency		60 Hz	60 Hz	60 Hz
Conductor Size	Existing	#2 AWG	#2 AWG	1/0 AWG
	New	#2 AWG, 1/0 AWG, 4/0 AWG	1/0 AWG	
Conductor Material	Existing	Copper and ACSR	Copper	Aluminum
	New	Aluminum	Aluminum	
Line Configuration	Existing	2-wire, ungrounded, insulators atop crossarms	2-wire, ungrounded, insulators atop crossarms	2-wire, ungrounded, Hendrix system
	New	Hendrix system	Hendrix system	
Load Served		Signal System Equipment	Signal System Equipment	Signal System Equipment

Appendix K - MEETING/TELEPHONE CONVERSATION RECORD

The following tables show a record of key meetings and conversations that took place during the Task 1 investigations.

Table K-1 - Meeting/Telephone Conversation Record - LTK

Date	Meeting/Telephone Call Initiator and Participants	Metra Staff	Conversation Summary
5/4/00	T. Kneschke	Representatives of various Metra departments	Project Kick-off Meeting
5/16/00	T. Kneschke/J. Mehdi	G. Loper, B. Johnson	Substation, tie station, and catenary inspection. Discussed condition of various types of equipment
5/16/00	T. Kneschke	G. Foyle, G. Hardwidge	Discussed planning and operational issues including platform lengths, suitability of longer trains and higher speeds and impact on the power and signal systems.
5/17/00	T. Kneschke, P. Kalke, & M. Golucki	Bruce Marcheschi	Meeting, discussed functionality of Metra's Communications System.
5/17/00	T. Kneschke, P. Kalke, A. Barker, J. Mehdi, & M. Golucki	George Loper, Tom Pavlik & Glen Gavril	Site visit, KYD and toured the PAL Center and various communications rooms. Then went to Metra's ROW at KYD to view catenary, L&P, and communication lines on the support structures. Lastly, viewed the same at the junction between Metra's Mainline and the Blue Island Branch.
5/17/00	T. Kneschke	J. Borowski	Tour of Randolph St. Station Facility, including the Operations Office, Traction Power Control Equipment and Two-Way Radio Control Console. Evaluated the lengths of platforms.
5/18/00	T. Kneschke C. Belser K. Vaidyan, S. Jha	Rich Soukoup	Overview, project objectives, car fleet
5/18/00	C. Belser, K. Vaidyan S. Jha, T. Kneschke Signal Drawing	Marty Ryan	Tour of KYD Shop and yard
5/19/00	T. Kneschke/J. Mehdi	G. Loper, B. Johnson	Substation, tie station, and catenary inspection. Discussed condition of various types of equipment
5/30/00	P. Novak	G. Gounaris	Collection of signal system data and information

Date	Meeting/Telephone Call Initiator and Participants	Metra Staff	Conversation Summary
5/31/00	H. Raundenbush, J. Pearson	M. Ryan, A. Humpries	Inspection of three cars at KYD
6/13/00	P. Novak	G. Gounaris	Collection of signal system data and information
6/15/00	T. Kneschke	Representatives of various Metra departments	Progress Meeting No. 1
6/22/00	P. Novak	G. Gounaris	Collection of signal system data and information
7/6/00	T. Kneschke/I. Hays/J. Mehdi	G. Loper, C.O. Kingery, R. Farnesi, R. Sanders	Site visits to evaluate overhead catenary system. Visit to KYD and Weldon facilities. Discussed catenary and pantograph maintenance, as well as carbon wear.
7/7/00	T. Kneschke/I. Hays	W. Szerla, K. Hodgson	Discussion on system development and data collection.
7/11/00	P. Novak	G. Gounaris	Collection of signal system data and information
7/19/00	J. Pearson	W. Koran	Telephone conversation on condition of cars.

Table K-2 - Meeting/Telephone Conversation Record - PTG, Inc.

Date	Meeting/Telephone Call Initiator and Participants	Metra Staff	Type and Conversation Summary
5/17/00	T. Kneschke, P. Kalke, & M. Golucki	Bruce Marcheschi	Meeting - Overall description and functionality of Metra's Communications System.
5/17/00	T. Kneschke, & P. Kalke	Randolph St. Station, Station Master	Meeting - Tour of Randolph St. Station Facility, including the Operations Office, Traction Power Control Equipment and Two-Way Radio Control Console.
5/17/00	T. Kneschke, P. Kalke, A. Barker, J. Mehdi, & M. Golucki	George Loper, Tom Pavlik & Glen Gavrill	Meeting - Started at KYD and toured the PAL Center and various communications rooms. Then went to Metra's ROW at KYD to view catenary, L&P, and communication lines on the support structures. Lastly, viewed the same at the junction between Metra's Mainline and the Blue Island Branch.
6/8/00	M. Golucki	Ken Hodgson	Phone Call & Meeting - L&P information request and pick-up of substation L&P single line diagrams.
6/8/00	P. Kalke	Bob Johnson	Phone Call - Requested a field visit of the 16th Street Substation.
6/8/00	P. Kalke	Paul Pavlika	Meeting - Visited 16 th Street Substation to review Comm equipment.
6/15/00	P. Kalke	Wes Szerla	Meeting - Phase I update meeting at Metra with LTK Team.
6/20/00	P. Kalke	Paul Pavlika	Phone Call - Arranged field visit for the Front Substation.
6/21/00	P. Kalke, A. Barker & M. Golucki	Paul Pavlika	Meeting - Met with Paul at 116 th St. / Front Substation to see new SCADA equipment and L&P system.

Date	Meeting/Telephone Call Initiator and Participants	Metra Staff	Type and Conversation Summary
6/21/00	P. Kalke	Bruce Marcheschi	Phone Call - Arranged a field visit and tour of CCF (1501 S. Canal).
6/22/00	P. Kalke & A. Barker	Bruce Marcheschi & Chris Kraker	Meeting - Toured CCF (1501 S. Canal) to view SCADA system and Comm equipment and links
6/27/00	Allan Barker	Wes Szerla	Meeting - Discussed obtaining any reference data Metra has produced on the L&P System.
6/28/00	Mark Golucki	George Loper	Phone Call - Asked if there was any previous Metra studies/reports available for the L&P System, and requested SCADA project drawings. and specifications. Was advised that no L&P studies were conducted but to contact Wes or Ken.

Table K-3 - Meeting/Telephone Conversation Record - STV, Inc.

Date	Meeting/Telephone Call Initiator and Participants	Metra Staff	Conversation Summary
5/23/00	S.N. Jha (STV)	Wes Szerla, Director, Electrical & Mechanical	Electrical operation of the Metra Electronic System
5/23/00	C. Belser, K. Vaidyan S. Jha, T. Kneschke	Rich Soukoup	Overview, project objectives, car fleet
5/23/00	C. Belser, K. Vaidyan S. Jha, T. Kneschke	Marty Ryan	Tour of KYD Shop and yard
5/31/00	S.N. Jha (STV)	Ray Sanders Skip Kingery	Operation of Weldon/18 th Street Yard
6/15/00	C. Belser, K. Vaidyan, S. Jha	Bill Archer Director of Engineering (312) 322-2745	Information regarding operation of various storage yards
6/28/00	S.N. Jha (STV)	Glenn J. Gavril (312) 322-2724	Information regarding type of switch heaters being used at various storage yard facilities
6/29/00	S.N. Jha (STV)	William Stokes (312) 322-2738	Problems with different types of switch heaters, gas versus electric